# CHAPTER 3

# ENERGY SAVING POTENTIAL IN HAWAII'S TRANSPORTATION SECTOR

## 3.1 INTRODUCTION

Chapter 2 projected future fuel demand in the ground, air and marine sectors based on existing transportation plans. These projections illustrate possible energy demand if present trends continue. This chapter explores possible energy conservation and efficiency improvements which could reduce energy demand in the state's transportation sector to below the levels projected in Chapter 2.

The analysis begins with an overview of energy conservation measures applicable to Hawaii's air and marine sectors. However, because Hawaii units of government have few means to actually encourage or impose conservation practices in these sectors, the focus of this chapter then shifts to the ground sector, where the opportunities for state and local implementation of efficiency improvements are greater.

Within the ground sector, this chapter begins with an examination of improvements in vehicular fleet energy efficiency. While a discussion of the means by which increased average fleet efficiency could be achieved is deferred to Chapter 11, it will be shown that, if implemented, increased fuel efficiency would have a significant effect on ground sector energy demand.

The discussion then moves to transportation control measures (TCMs). TCMs initially focused on low-cost improvements to better accommodate transportation demand. Initially, most of the specific measures were transportation system management (TSM) measures that emphasize improving the operating efficiency and maximizing the capacity of the existing transportation system. They usually address localized concerns. Examples of these TSM measures are one-way streets, reversible (contra-flow) lanes, additional bus service, signal timing and synchronization, and similar actions. TSM measures focus on the "supply side" of transportation service.

As system efficiency improves, one might expect that, all other factors remaining constant, transportation energy usage would decrease because of a decrease in traffic congestion. However, the actual situation is not quite this simple for two principal reasons.

First, as transportation system efficiency improves, other factors change. For example, it has been shown repeatedly that there is a latent demand for transportation service. As system efficiency improves and level-of-service (LOS) for travelers improves, additional trips are typically generated. Previously, before the system improvements, these trips would have been foregone.

Second, energy efficiency of internal combustion engine vehicles varies in a complex fashion with vehicle speed. Vehicle efficiency decreases dramatically at speeds below 15 miles per hour. Results of one study indicate that fuel consumption (in miles per gallon, mpg) increases by 30 percent when average speeds drop from 30 to 20 miles per hour. A decrease from 30 to 10 miles per hour results in a 100 percent increase in fuel consumption (California Energy

Commission, 1992b). At lower speeds, various frictional losses predominate.[1] At higher speeds, friction from aerodynamic drag predominates. Somewhere in the middle, at a speed specific to each vehicle but often around 25-35 mpg for a passenger car, maximum fuel efficiency is attained. Therefore, if average speeds increase through transportation system efficiency improvements, depending on the initial speed and the amount of its subsequent change, average fuel efficiency could increase or decrease.

A method developed by the Texas Transportation Institute and used in a report on congestion for the Federal Highway Administration (FHWA) was used to estimate the impact of congestion on energy usage (Schrank, et. al. 1993). The report estimates fuel wasted due to congestion for the years 1986 through 1990 for the City and County of Honolulu. Based on these estimates and state data on fuel consumption in the ground sector for these years, energy wasted from congestion increased from approximately eight percent to ten percent of the total ground sector transportation energy demand on Oahu in those years. The method of Schrank, et. al. (1993) was used to develop estimates of future energy waste from congestion, as reported in Chapter 2.

During the 1980s, the analysis of TCMs expanded to programs that could reduce travel demand, as measured by vehicle trips in congested areas during peak travel periods. Importantly, reducing vehicle trips during the peak periods and in areas of congestion does not necessarily imply reducing person trips. Examples of these transportation demand management (TDM) measures includes enhancing and promoting, and in some cases mandating:

- shifts in transportation mode from single-occupant vehicles (SOVs) to high-occupancy vehicles (HOVs) which are characterized by higher utilization efficiencies (occupants per vehicle), such as commuter vans, buses, car-pools, rail transit vehicles or jitneys;
- shifts to travel during less congested periods ("spread the peak period of travel");
- shifts in choice of travel mode away from motorized vehicles to such modes as bicycling or walking; and
- elimination of the need for travel.

As used in this report, the term TCM encompasses both TSM measures and TDM measures. These two categories are not rigid, however. Also, synergies among TCMs are frequent, and several TCMs are often proposed as a package. Common goals of most of them are to encourage modal shifts from SOVs to some form of HOV, shift the time of travel, and/or reduce the need for travel.

This chapter reviews a large number of TCMs that have been discussed for possible implementation in Hawaii. Over the long term, however, fundamental land use patterns are perhaps the most important factor controlling transportation requirements and the form of the transportation network. With much of the state still not developed in an urban fashion, and with redevelopment opportunities (such as Kakaako), the implementation of wise land use planning practices could provide a future land use pattern in some areas which could then be served

[1] It should be noted that, with standard automobile engines, if the engines are running but the vehicles are not traveling (for example, when stopped in stop-and-go traffic conditions) the vehicles are burning fuel with an efficiency of zero miles per gallon. Electric vehicles consume little or no energy when stopped. Thus, electric vehicles offer superior energy efficiency in a congested environment.

by an energy-efficient transportation network that, among other characteristics, facilitates bicycling and walking. This chapter discusses some of the current land use planning concepts which could have the effect of reducing transportation energy demand.

Finally, some concluding remarks are offered about the potential of energy conservation in Hawaii's ground transportation sector.

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## 3.2 ENERGY EFFICIENCY IN THE AVIATION AND MARINE SECTORS

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### 3.2.1 COMMERCIAL AVIATION

Spurred on by the petroleum price shocks of the past decades, air transportation has doubled its energy efficiency since the early 1970s. Higher load factors, increased aircraft size, changes in the usage of existing aircraft, selective retrofitting of existing aircraft, and the introduction of more energy-efficient turbofan aircraft have all been implemented. Passenger load factors (the percent of available seats occupied by paying passengers) increased from 50 percent in 1970 to 60 percent in 1980, and stood at 64 percent in 1989 (Davis and Morris, 1992). Average available seats per aircraft increased from 111 in 1970 to 163 in 1985, but declined to 158 in 1989 (this slight, recent decline could be a result of providing more frequent service to hub airports). The provision of more fuel-efficient turbofan planes (rather than the conventional turbo jet) also brought about dramatic improvements in energy efficiency.

Energy efficiency of air transportation in the U.S. has waned in the last few years despite increases in load factors between 1984 and 1989. One factor could be the increase in air traffic congestion, compounded by greater "hubbing" by airlines, which has resulted in greater delays and ground time. Another factor could be that fuel prices have generally stabilized since the late 1980s. In 1970, kerosene jet fuel cost $0.30 (1989 $) per gallon. This doubled to $0.61 per gallon in 1975 and peaked at $1.37 per gallon in 1981. Prices dropped in the late 1980s to around $0.60 per gallon. Cheaper fuel reduces the pressure for airlines to convert to more fuel efficient, but expensive, turbofan engines.

The current U.S. commercial fleet has an average efficiency of about 48 seat-miles per gallon (SMPG). Future gains in commercial aviation energy efficiency could be obtained through technological improvements to engines and airframes,[2] technological and procedural

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2 Since the 1960s, the jet engine has evolved from the turbojet technology to turbofans and then high-bypass turbofans. This progression has produced a 40 percent increase in efficiency. Current high-bypass engines achieve their efficiency by sending 5-6 times as much air around the core as the original straight turbojet engines. This by-pass flow is then accelerated by fans which are driven by the turbine engine. This technology results in greater thrust per pound of fuel consumed than turbojets.

A major propulsion efficiency advance could be realized with ultra-high-bypass engines that boost the bypass ratio from current levels of 6 to 7 up to 15 to 20. Another promising technology is the advanced unducted, or propfan, engine. This technology uses twin counter-rotating propellers, which can achieve a 30 percent increase in fuel-economy over the best current turbofan engines. Their high cost (they cost about twice as much) and concerns about noise, vibration, and maintenance are delaying their acceptance.

improvements to the air traffic control system, and improvements in the use and deployment of planes[3] (Greene, 1992). Average fleet efficiencies of 58 SMPG by the year 2000 and 65 SMPG by 2010 (Greene, 1992) have been discussed, which would represent 20.8 percent and 35.4 percent increases, respectively, over the current average SMPG.

### 3.2.2 MARINE SECTOR

Energy saving strategies in the marine sector include fuel-efficient operating procedures, manufacturer engine exchange programs, and engine downsizing (Argonne National Laboratory, 1991).

Improvements in operating procedures could save energy. Crew training would be required and financial incentives for fuel-efficient operations could be offered (Argonne National Laboratory, 1991).

Marine engines, especially those found in tugs, are typically two-stroke diesels with long operating lives. Four-stroke diesels, with higher stroke-to-bore ratios, are available and their use would reduce fuel consumption by 5 to 10 percent or more. The longevity of marine engines slows their replacement rate, however. Manufacturers' exchange programs could be implemented.

Replacing existing engines with less powerful ones could also achieve energy savings since diesels operate most efficiently at full power, and marine engines typically operate well below full power. However, use of this technique would depend on specific details of each vessel.

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Another technological advance expected to bring increased fuel efficiency is in the field of advanced, high-temperature materials that will permit an increase in ignition and combustion temperatures, and reduce engine weight (Greene, 1992). Advanced light-weight ceramic and metal composite materials could allow an increase in turbine inlet temperatures to over 2500°F while reducing engine weight. At present, the brittleness and sensitivity to flaws of these materials inhibit their use (Greene, 1992).

Energy-efficiency improvements may also be achieved by reductions in aerodynamic drag and airframe weight. At low speeds, air flows over an airfoil (wing) in smooth streamlines (laminar flow). As speed increases, a greater fraction of the air flow becomes turbulent, greatly increasing drag. Advanced supercomputer simulations are being used to help design wings that maintain laminar flow at high speeds. Design concepts include the "smart wing," which would automatically change shape during flight. Another concept would be a wing with grooves or microscopic holes towards the front (through which air would be drawn to reduce turbulence) and ultra-smooth wing surfaces behind to maximize natural laminar flow.

It is not presently feasible to achieve laminar flow over fuselages because of the turbulence they create. Large-eddy breakup (LEBU) devices (inserting small grooves aligned with the direction of airflow and thin plates suspended in the turbulent layer around the fuselage) have been shown in wind tunnel tests to reduce frictional drag by as much as 10 percent (Greene, 1992).

New composite lightweight materials could reduce airframe weight by 30 percent while achieving equal or better structural strength (Greene, 1992). The next century may see planes of 80 percent composite materials in contrast to today's commercial planes, which are 97 percent metal. Lighter airframes require smaller engines, lighter engines allow reductions in an airframe's mass, and both reduce energy requirements.

3 Airport congestion will necessitate the use of increasingly large planes. Boeing expects that more than half the seats that it will produce after 1995 will be in aircraft of 350 seats or more, and two thirds of the aircraft that it expects to sell would have more than 170 seats (Greene, 1992). Larger planes are generally more efficient in terms of SMPG. Therefore, the trend towards larger planes should increase overall fuel economy.

Greater airport congestion will also require improved tools for controlling airport operations (Greene, 1992). Increasing the number and size of airports has been the historic means of combating air traffic congestion. However, given the scarcity of land in many metropolitan areas, and the environmental impacts associated with airport development, the viability of this option is decreasing in most places. Capacity-building measures must be implemented, such as reducing radar scan frequency to 0.5 seconds (short scan), reducing aircraft stagger or lateral separation to 1.5 miles, reducing aircraft spacing from 4,300 to 2,500 feet on parallel runways, and shortening converging runway requirements (Argonne National Laboratory, 1990). However, given the expected increases in air traffic, improvements to airport operations may only maintain present levels of service.

New engine technologies, such as turbo-compounding and rankine bottoming cycles, have demonstrated fuel savings of 5 to 7 percent and 12 percent, respectively (Argonne National Laboratory, 1991).

### 3.2.3 LOCAL CONTROL OVER ENERGY USE IN AIR AND MARINE TRANSPORTATION

While it appears that there are significant energy-saving opportunities in both the air and marine sectors, the opportunity for government in Hawaii to accelerate the implementation of these measures is limited. The ability of any state to regulate aircraft and merchant vessels involved in international or interstate commerce is small. Hawaii is also a small market, and not in a position to affect the offerings of engine, plane and ship manufacturers, or influence owner purchase requirements.

Because of the limited scope for Hawaii's government to affect energy conservation in the air and marine sectors, the rest of the discussion focuses on Hawaii's ground sector.

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## 3.3 ENHANCED GROUND TRANSPORTATION VEHICLE FUEL EFFICIENCY STANDARDS

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One means of decreasing energy demand in the ground sector would be to increase the average fuel efficiency of the vehicles. The production of more fuel-efficient vehicles is not technically difficult. In 1994, the Environmental Protection Agency (EPA) rated five subcompacts as having fuel efficiencies greater than 47 mpg. Car manufactures argue that the more fuel efficient vehicles are hard to sell given current, relatively low gasoline prices. Technology exists, however, to substantially increase fuel economy. Before discussing implementation mechanisms and issues, it is informative to estimate how much energy could be saved through fleet efficiency improvements. The discussion of implementation mechanisms and issues is deferred to Chapter 11.

It is important to note that the efficiency improvements assumed in the Chapter 2 estimates become quite dominant by 2014, when efficiency is projected to be 38 percent higher than in 1992. Such improvement would start to cause energy demand to decrease even as transportation activity increases. However, achieving such improvement is speculative. The fundamental point is that efficiency has a powerful effect on energy demand, and the efficiency improvements assumed in Chapter 2 would, of themselves, save much energy.

The federal Corporate Average Fuel Economy (CAFE) standards law[4] preempts (prohibits) states from setting their own fuel efficiency standards. However, it is not inconceivable that this could change. What would be the effect if Hawaii were to improve upon the efficiency improvements in Chapter 2? Large effects would indicate that it could be desirable to amend the federal law or approach fuel efficiency indirectly. The approach taken here was to use a

[4] Title V of the Motor Vehicle Information and Cost Savings Act, 15 U.S.C. 2001-2013.

fuel efficiency factor that was either 5 or 10 percent above the baseline energy efficiency improvements that were assumed in the initial projections (see Appendix A-1 for a more complete discussion of the calculation method). The future baseline calculations were based on projected average fleet efficiencies as reported in The Forecast of Transportation Energy Demand Through the Year 2010 (Argonne National Laboratory, 1991).

Projected energy savings through increased fleet efficiency are shown in Table 3-1. If Hawaii were to implement fuel efficiency standards higher than the nation, energy would be saved. The estimates in Table 3-1 are somewhat high because fleet turnover has not been considered. The savings are large enough to suggest that the state could consider means of influencing the fuel efficiency of vehicles in the state.

In summary, modifying fuel efficiency is a powerful means of controlling energy demand.

## 3.4 GROUND TRANSPORTATION CONTROL MEASURES (TCMS)

### 3.4.1 BACKGROUND

TCMs (defined above in Section 3.1) are currently much discussed because of public frustration with growing traffic congestion problems. On Oahu, given the loss of funding for Honolulu's rail transit program in 1993, and the prominent position that the rail system had in Oahu transportation plans, government leaders and citizens' groups are re-examining a wide array of TCMs to deal with congestion problems.

TCMs that have been discussed for application on Oahu are summarized in Table 3-2, and include the following:

- Operational modifications to improve traffic flow;
- Intersection and roadway modifications;
- Freeway operation modifications;
- Roadway enforcement and management;
- Vehicle use limitations;
- High occupancy vehicle (HOV) facilities;
- Intelligent Transit, ("smart street/vehicle concepts");
- Bicycle and pedestrian facilities;
- Public transit expansion;
- Operational improvements in transit service;
- Park-and-ride facilities;

## Table 3-1

## Energy Savings with Hawaii Vehicle Efficiencies Higher than National Average

| Year | National Baseline (MPG) | 5% Improvement Over National Baseline[1] (Barrels of Gasoline) | 10% Improvement Over National Baseline[1] (Barrels of Gasoline) |
|---|---|---|---|
| 1996 | 19.00 | 511,726 | 1,023,451 |
| 1999 | 19.60 | 527,758 | 1,055,515 |
| 2004 | 21.00 | 549,090 | 1,098,179 |
| 2014 | 22.40 | 590,190 | 1,180,379 |

Note:
1) National baseline is the vehicle efficiency projected for the nation in the Forecast of Transportation Energy Demand through the Year 2001 (Argonne National Laboratory, 1991).

# Table 3-2

## Summary of Transportation Control Measure Effectiveness

| Measure | Effective Period | Measure of Effectiveness | Level of Effectiveness[1] | Observed Locations |
|---|---|---|---|---|
| **1. Operational Modification to Improve Traffic Flow** | | | | various on Oahu |
| Conversion of a street pair to one-way operations | | vehicular capacity | 10-20% increase | |
| Reversing one lane on a six-lane roadway | peak hours | vehicular capacity | 33% increase | |
| Conversion of on-street parking to one lane | | vehicular capacity | proportional to number of lanes | |
| Traffic signal coordination | | travel time | at least 10-20% reduction | |
| Traffic signal coordination | | vehicular capacity | small increase | |
| **2. Intersection and Roadway Modifications** | | | | |
| Prohibition or separation of left-turn vehicles | peak hours | vehicle queuing & delays | 20-30% reduction | various |
| **3. Freeway Operations** | | | | Detroit, Los Angeles, Minneapolis & numerous other metropolitan areas |
| Ramp metering | peak hours | travel volumes | 10-20% increase | |
| Ramp metering | | travel speeds | 30-40% increase | |
| Ramp metering | | travel time | 10-40% reduction | |
| Ramp closures | | travel time | increase for some drivers | |
| **4. Roadway Enforcement and Management** | | | | |
| Incident management systems | | congestion | 30% decrease | major urban highway |
| Non-stopping zones, parking restrictions | peak hours | travel speed | increase | Boston |
| Non-stopping zones, parking restrictions | peak hours | travel time | >30% reduction | Boston |
| Non-stopping zones, parking restrictions | peak hours | vehicular capacity | 30-40% increase | Boston |
| Incident patrol | peak hours | congestion | <60% decrease | Chicago |
| **5. Vehicle Use Limitation** | | | | |
| Auto licensing scheme In Central Business District | | inbound vehicle trips | 50% reduction | Singapore |
| Auto restrictions iin Central Business District | | traffic volumes | 5% reduction | Boston |
| **6. High Occupancy Vehicle (HOV) Facilities** | | | | |
| HOV lanes with other TSM measures | | auto trips | 10-15% reduction | California |

## Table 3-2

## Summary of Transportation Control Measure Effectiveness
**(continued)**

| Measure | Effective Period | Measure of Effectiveness | Level of Effectiveness[1] | Observed Locations |
|---|---|---|---|---|
| **7. Intelligent Transit ("Smart Street/Vehicle Concepts")** | | | | |
| Automated message signs | | traffic volume | 5-10% diversion in advance | New York State |
| Controlled segments | | traffic accidents | 5% decrease | New York State |
| **8. Bicycle and Pedestrian Facilities** | | | | |
| Bicycle use | | participation | 3-11% increase | national study |
| Walking | | participation | 3-16% increase | national study |
| Effect on auto travel | | mode switch | 1% from auto to non-auto | California |
| **9. Public Transit Expansion** | | | | |
| Expansion of trunk and collector bus route service | | ridership | 0.3-0.8% increase per 1% increase in bus service | |
| Reduced headways/increased frequency of service | | ridership capacity | 0.5% increase per 1% increase in frequency | |
| **10. Operational Improvements in Transit Service** | | | | |
| Removing selected stop signs | | travel time | 5-15% reduction | San Francisco |
| Parking and traffic enforcement | | time passing intersection | 30% reduction | San Francisco |
| Bus pre-emption | | number & duration of delays | 75% - 90% and 6 to 11 seconds reduction | San Francisco |
| **11. Park-And-Ride Facilities** | | | | |
| Parking-and-ride facilities | | vehicle mile traveled | 1-4% reductions | Texas and Connecticut |

## Table 3-2

## Summary of Transportation Control Measure Effectiveness (continued)

| Measure | Effective Period | Measure of Effectiveness | Level of Effectiveness[1] | Observed Locations |
|---|---|---|---|---|
| **12. Public-Transit Marketing** | | | | |
| Fare structure/pricing | | transit ridership | 0.3% increase per 1% and decrease in fare | |
| Voucher programs | | transit ridership | up to 17% increases | |
| Regional transit guides | | transit ridership | 15-20% increases | New York City |
| **13. Paratransit - Premium Subscription Express Bus Service** | | | | |
| Premium subscription express bus service | | travel times | competitive with the auto | |
| **14. Paratransit - Jitneys** | | | | |
| Jitneys services | daily | traffic volume | 0.15% decrease | Oahu (studied) |
| Jitneys services | peak hour | traffic volume | 0.5% decrease | |
| **15. Paratransit - Shared Ride Taxi** | | | | |
| Shared ride taxi services | | rider trips | 50-100% increase than single ride taxi | |
| **16. Guaranteed Ride Home** | | | | |
| Guaranteed Ride Home | | solo driving trips | 71% reduction (in trips made by the 8.5% solo drivers in study) | Bellevue, Washington |
| Guaranteed Ride Home | | bus trips | 12% increase | Bellevue, Washington |
| Guaranteed Ride Home | | carpool trips | 2% reduction | Bellevue, Washington |
| Guaranteed Ride Home | | vanpool trips | 64% increase (mostly carpool participants switching to van pools) | Bellevue, Washington |

## Table 3-2

## Summary of Transportation Control Measure Effectiveness (continued)

| Measure | Effective Period | Measure of Effectiveness | Level of Effectiveness[1] | Observed Locations |
|---|---|---|---|---|
| **17. Areawide Rideshare Program** | | | | |
| Vanpool programs | | total VMT | 0.05-0.28% reduction | |
| Vanpool programs | | work trip VMT | 0.14-0.10% reduction | |
| **18. Controls Affecting Parking Supply** | | | | |
| Parking constraints | | traffic volume in the area | >5% reductions | Downtown Honolulu |
| Charge options | | commuting trips | 11% reductions | financial district |
| Charge options | | commuting trips | 16-20% reductions | C&C, State of HI |
| Cash out | | commuting trips | 7% reductions | financial district |
| Cash out | | private sector trips | 7.5-12.4% reductions | various-Oahu |
| Charge with travel allowance | | commuting trips | 9% reductions | financial district |
| Charge with travel allowance | | commuting trips | 13-16% reductions | C&C, State of HI |
| Parking options | | commuting trips | 10-15% reductions | Kakaako |
| **19. Pricing Actions Affecting Parking** | | | | |
| Doubled long-term parking rates | | parking volume | long-term parking decreased | |
| Doubled long-term parking rates | | parking volume | short-term parking increased | |
| **20. Employer Parking Pricing and Supply Actions** | | | | |
| Cash out | | solo driving | 24% reduction | Los Angeles |
| Charge federal employees for parking | | commuting trips | 1-10% reductions | central city areas |
| Charge federal employees for parking | | solo driving | 21% reduction | Ottawa |
| Charge market rates for parking | | solo driving | 12% reduction | |
| Parking pricing | | solo driving | 17% reduction | Bellevue City Hall |
| Parking pricing | | solo driving | 25% reduction | CH2M Hill |
| Parking pricing | | solo driving | 25% reduction | 20th Century Corp. |

## Table 3-2

## Summary of Transportation Control Measure Effectiveness
**(continued)**

| Measure | Effective Period | Measure of Effectiveness | Level of Effectiveness[1] | Observed Locations |
|---|---|---|---|---|
| Parking pricing | | solo driving | 55% reduction | U.S. West Bell |
| Parking pricing | | solo driving | 34% reduction | Commuter Computer |
| **21. Employer-Based Rideshare Programs** | | solo driving | various reduction rates | various U.S. locations |
| **22. Variable Work Hours** | | | | |
| Staggered hours | | travel time | 10% reduction | downtown Honolulu |
| Compressed work week | | solo driving | 5% reduction | Ventura County |
| **23. Telecommuting** | | | | |
| Telecommuting programs | daily | work trips | 30% reduction | State of California |
| Telecommuting programs | | fuel consumption | 29% reduction[2] | C&C Honolulu |
| **24. Transportation Management Associations (TMA)** | | | | |
| TMA actions | | solo driving | 3% reduction | Hartford |
| TMA actions | | solo driving | 5% reduction | Irvine, Orange County |
| TMA actions | peak time | solo driving | 35% reduction | Hacienda Business Pk. |
| **25. Trip Reduction Ordinances** | | solo driving | various reduction rates | various U.S. locations |
| **26. Actions by Educational Institutions** | | | | |
| Starting school day 1 hour later | | travel time to Primary Urban Center (PUC) areas | 15-20% reduction | Hawaii |

## Table 3-2

## Summary of Transportation Control Measure Effectiveness
### (continued)

| Measure | Effective Period | Measure of Effectiveness | Level of Effectiveness[1] | Observed Locations |
|---|---|---|---|---|
| **27. Pricing or Other Control of Automobile Use** | | | | |
| Road pricing | peak time | traffic volume | 40% reduction | Singapore |
| Road pricing | | traffic volume | 20% reduction | Hong Kong |
| Road pricing | | auto trips | 28% reduction | to Stockholm City |
| Road pricing | | auto trips | 6% reduction | Stockholm County |
| Road pricing | | vehicular speeds | 30% increase | Stockholm C&C |
| Road pricing | | traffic volume | 37% reduction | London |
| Road pricing | | auto trips | 10-20% reductions | Boston, NYC |
| Road pricing | | auto trips | 10-20% reductions | SCAG |
| **28. Land Use Patterns and Energy** | | | | |
| Good accessible design | | vehicle mile traveled | 30% reduction | New Jersey |

Source: Wilbur Smith Associates, May 1992.

Notes:
1) Effectiveness is typically restricted to a travel corridor or other locations. Effectiveness is also highly specific to the details of the program being evaluated typically.
2) In one office.

- Public transit marketing;
- Paratransit-premium subscription express bus service;
- Paratransit-shared ride taxi;
- Guaranteed ride home;
- Areawide rideshare programs;
- Controls affecting parking supply;
- Pricing actions affecting parking;
- Employer parking pricing and supply actions;
- Employer-based rideshare programs;
- Variable work hours (includes variable work weeks);
- Telecommuting;
- Transportation management associations;
- Trip reduction ordinances;
- Actions by educational institutions;
- Pricing or other control of automobile use;
- Land use patterns; and
- Energy-saving effectiveness of the identified TSM measures.

When considering the energy consequences of TCMs, several factors must be recognized. First, TCMs were not developed to reduce energy demand. In general, they were developed to increase mobility and reduce air pollutant emissions. Other goals of TCMs are to increase capacity or reduce traffic congestion. While relieving congestion could intuitively suggest decreasing energy demand by decreasing travel time and affecting average speed (for a more complete discussion of the effects of congestion on energy demand, see Section 3.1), some TCMs could actually increase energy demand. For example, bus priority measures (see Section 3.4.2.10) could decrease levels of service for SOVs by increasing their waiting times at intersections. Net energy effects could be positive or negative, depending on the specifics of the situation.

Even when a TCM does not work directly against energy conservation, TCMs could indirectly increase energy demand by improving system operations, thereby encouraging SOV use and generating additional trips.

Since congestion is frequently caused by localized traffic choke points, many TCMs are designed to address the bottleneck. Their effects are spatially and/or temporarily localized and they have no effect on total regional vehicle miles traveled (VMT). For example, measures to decrease peak travel demand, such as staggered work hours, have no effect on total regional VMT over a 24-hour period, and therefore have a minimal impact on energy demand. However, if the TCM succeeds in reducing localized congestion over the long term, some energy savings may be achieved.

In summary, TCMs were designed to affect travel performance. Energy saving could be a by-product, but is not usually a primary goal.

The effectiveness of TCMs is best predicted by running traffic models that incorporate detailed, accurate, validated input parameters. There are very few such modeling studies for Hawaii that are readily available, regionally applicable and produce data that could be directly entered into an energy saving calculation. Therefore, the approach followed in this project is primarily to qualitatively discuss TCM effectiveness, and where possible, summarize quantitative estimates from selected studies. (See, for example, section 3.5 which reports some results based on traffic modeling for combinations of TCMS.)

The Oahu Metropolitan Planning Organization (OMPO), a state and County organization responsible for coordinating transportation planning efforts on Oahu, began a study to develop TCM recommendations for Oahu in November, 1991. The first phase of the study, an initial screening of both supply-side (TSM) and demand-side (TDM) actions, concluded with the 28 TCMs listed at the beginning of this section in the Transportation Systems Management Study: An Interim Working Paper Initial Screening of Actions (Wilbur Smith Associates, 1992). In July 1992, 6 of the 28 actions were chosen by the OMPO Policy Committee to be more closely studied. These six TCMs were:

- preferential bus treatments;
- private premium bus service;
- jitney services;
- parking supply controls;
- alternatives to employee parking subsidies; and
- educational system actions.

In January 1994, 17 of the original 28 actions were endorsed by the OMPO Policy Committee. Currently, these 17 actions have been forwarded to the appropriate state, City and County, and private agencies for review. The 17 that have moved forward are:

- HOV lanes;
- expansion of TheBus service capacity;
- control of parking supply;
- reduction of employee parking subsidies;
- educational system actions;
- telecommuting and teleconferencing;
- park-and-ride facilities;
- guaranteed ride home;
- variable work hours;
- transportation management associations;
- areawide rideshare program;

- jitneys;
- land use provisions;
- premium subscription bus services;
- road pricing;
- trip reduction ordinance; and
- vehicle use limitations.

Starting in December 1992, the Transportation Committee of the City Council also sponsored a planning process of TSM measures through its Transportation and Traffic Management Task Force. This Task Force has produced a report which focuses on increasing the efficiency of present transportation facilities through expanding public transit and TSM measures. This report recommends increasing the use of HOV lanes, especially in the urban area. The energy consequences of the TSM measures are not explicitly addressed in this report, however.

## 3.4.2 TRANSPORTATION CONTROL MEASURES PROPOSED FOR OAHU

The purpose of this section is to describe in more detail many of the measures that have been suggested to help alleviate Honolulu's traffic congestion problems. An attempt is made to close the discussion of each TCM with an assessment of its potential to affect regional VMT, and thereby achieve energy savings.

### 3.4.2.1 Operational Modifications To Improve Traffic Flow

Operational modifications increase capacity, thereby alleviating congestion, improving traffic flow, reducing travel times and, to some degree, reducing energy wasted in congestion. Such improvements could be implemented without the impacts or costs associated with major reconstruction or widening projects. Such actions include:

- *Conversion of two-way streets to one-way operation:* Under specific circumstances, this technique has increased capacity 10 to 20 percent above two-way operations (Wilbur Smith Associates, 1992). Conversion could increase VMT slightly due to the more circuitous routes which are sometimes required when utilizing a network of one-way streets.
- *Reversible and contra-flow lanes:* The increase in capacity resulting from reversible or contra-flow operation is generally proportional to the change in number of lanes.
- *Curb lane parking restrictions:* This technique could provide increased capacity equivalent to the increase in the number of lanes. Parking restrictions also improve bus travel times.
- *Traffic signal interconnection and coordination:* This measure could improve travel times by 10 to 20 percent or more on the favored streets, and could also produce small increases in vehicular capacities. Services could deteriorate on streets which are not favored by the synchronization.

State Department of Transportation (SDOT) and Department of Transportation Services (DTS) have implemented many such roadway operational improvements, such as contra-flow lanes on Kalanianaole Highway and Kapiolani Boulevard, one way operation on Punchbowl and other downtown streets, signal synchronization of 290 intersections in the Downtown area and curb lane parking restrictions on several streets.

Because each of these actions generally improve traffic flow and reduce delays, they can actually encourage SOV usage and stimulate additional trips. Energy conservation effects could thus be offset by additional travel induced by improved system performance. In addition, with these types of measures, improvements are highly localized. Adjacent areas could actually experience deterioration in service when some street system modifications are implemented.

The effect of this TCM on regional VMT and therefore energy demand would be minimal.

#### 3.4.2.2 Intersection And Roadway Modifications

Intersection geometries and traffic characteristics sometimes produce operational problems. Some could be mitigated by localized physical or operational modifications. For example:

- *Addition of left-turn lanes to provide a stacking area; prohibition of left-turn movements; and separate left-turn phases at signals*: These measures could reduce queuing and delays by 20 to 30 percent for left-turn vehicles that would otherwise experience long waits for gaps in opposing traffic.
- *Construction of raised islands and corner rounding:* This technique could improve intersection capacity by increasing speeds through the intersection.
- *Modified traffic signal phasing and timings to most efficiently accommodate traffic patterns:* This technique is similar to one described in Section 3.4.2.1., but adds variation in the synchronization pattern where traffic characteristics change substantially through the day.
- *Pullouts at bus stops so that stopped buses do not block through traffic:* This geometric improvement could eliminate delays caused by stopped buses blocking traffic lanes, significantly increasing the vehicular capacity of the roadway. Buses could experience delay in reentering the travel lanes.

Localized roadway modifications such as those described above are numerous in Honolulu and are regularly implemented through City and state programs, and traffic impact mitigation requirements placed upon developers. As only one example, bus pullouts recently installed on Kapahulu have substantially increased the capacity of this road.

The effect of this TCM on regional VMT and energy demand would be minimal.

#### 3.4.2.3 Freeway Operations

Several operational strategies could be implemented to maximize existing highway capacity. For example:

- *Ramp Metering:* This measure improves traffic flow on freeways by relocating delays to the on-ramps, and discouraging use of the freeway for short trips. Effectiveness depends on the severity of congestion and specifics of the metering program. Ramp metering could result in 30 percent increases in peak period travel speeds, 20% increases in traffic volumes and 10 to 40 percent decreases in travel times (Wilbur Smith Associates, 1992).

- *Ramp Closures:* As an extreme form of ramp metering, entry prohibitions to the freeway could be implemented on a selective basis, such as during peak periods. The closure of heavily used ramps during peak periods, which could result in increased travel time and inconvenience for affected motorists, could be highly effective in increasing transit use. Partial closures, which limit ramp use to buses or other HOV, are also very effective.
- *Use of Shoulder Lanes:* This technique is a low cost measure to quickly increase highway capacity during an interim period. Such lanes are created from the existing paved shoulder. Additional lanes can also be provided in some situations by reducing the width of the through lanes. Although travel speeds and safety could be adversely affected, these aspects could be partially mitigated by proper signage, enforcement, and the construction of turnouts to store disabled vehicles.

With federal approval, state government could implement improvements in freeway operations. The feasibility of ramp metering in Honolulu was studied for the H-1 Freeway in the late 1970s as part of a state-sponsored evaluation of traffic surveillance and control systems, geometric modifications, intersection improvements, signal system improvements, and preferential treatments for bus transit. However, ramp metering has not been implemented because of concerns about adequate queuing areas at on-ramps, and insufficient capacity to accommodate the traffic diverted from the freeway on alternate routes.

The effect of this TCM on regional VMT and energy demand would be minimal.

### 3.4.2.4 Roadway Enforcement And Management

Roadway enforcement and management includes not only freeway operation strategies (ramp metering, ramp closure and use of shoulder lanes) that were discussed above, but also incident management systems, diversion and advisory signage, surveillance, control and enforcement. The emphasis here is on unpredictable incidents caused by accidents or bad weather. Reducing delays caused by such incidents could save energy.

Incidents are managed by such measures as:

- pre-positioned or roving tow trucks;
- closed circuit TV at key intersections and freeway sections;
- variable message signs advising the use of alternate routes;
- aerial surveillance (traffic helicopters);
- roadside call boxes; and
- a control center staffed to provide traffic engineering and police coordination for quick incident response.

These strategies help maintain capacity through the timely clearance of the capacity-limiting incident, and/or by controlling and rerouting traffic during the incident. A 1986 FHWA study

(Wilbur Smith Associates, 1992) indicated that incident management systems could reduce congestion on approximately 30 percent of major urban area highway mileage. For example, a program in Boston produced an increase in speeds on the affected arterial, and corresponding travel time reductions of over 30 percent. VMT were not reduced, but vehicle hours of travel was reduced by 5 percent. Such a reduction in vehicle hours might save energy.

State and City agencies have enforcement and incident management programs (e.g., Capt. Irwin), and additional programs are being implemented, such as the variable traffic message signs proposed for deployment at 50 locations around Oahu.[5]

Types of traffic enforcement that maintain flow include:

- enforcement of intersection blockage restrictions to avoid gridlock;
- enforcement of "no parking" and "no standing or stopping" restrictions;
- enforcement of left-turn restrictions; and
- enforcement of HOV lane usage.

Such measures help prevent and ease congestion.

The effect of this TCM on regional VMT and energy demand would probably be minimal.

#### 3.4.2.5 Vehicle Use Limitations

Vehicle use limitations are designed to discourage vehicles, particularly SOVs and trucks, from entering congested areas during peak periods by increasing costs and decreasing convenience. The desired public response would be shifts to alternative travel modes, like HOVs, walking, bicycling or avoidance of the peak period. Because these measures are disincentives and decrease traveler convenience, their implementation could be controversial. Examples include:

- *Auto-restricted zones:* Such zones restrict traffic from certain streets or precincts temporarily or permanently. Singapore's Area Licensing Scheme (ALS), which limits the automobiles entering the Central Business District (CBD), is a well-known example of a vehicle use limitation strategy. Morning peak access to the CBD is restricted to vehicles with special licenses purchased at a premium fee, and vehicles with three or more occupants. The program resulted in a significant shift of travelers from auto to transit. The measure has also resulted in staggered work hours so that some portion of the commuters avoid the peak period. Similar programs in Boston reduced traffic volumes in the downtown restricted zone by 5 percent, mainly due to a shift in travel mode (Wilbur Smith Associates, 1992).
- *Pedestrian malls:* Street closures in downtown Honolulu have been implemented to create pedestrian and transit malls (e.g. Fort and Hotel Street malls).

5 Deployment of the signs is causing controversy for several reasons, such as perceptions of visual intrusion and lack of options in response to certain messages.

- *Time restrictions on truck deliveries:* Such measures prohibit truck deliveries during peak periods.
- *Gas rationing:* This severe measure would regulate VMT by regulating the supply of energy.
- *Restricted travel days:* This measure restricts travel on certain days (e.g., odd-, even-travel days).

To maximize effectiveness and political palatability, these disincentives must be accompanied by enhancing alternatives to SOV travel, such as preferential treatment for transit, express buses, park and ride lots, and other measures that enhance HOVs.

Government could implement restricted zones on Oahu. The areas most commonly mentioned for implementation of an ALS are Downtown and Waikiki. Implementation issues include the adequacy of transportation alternatives, provisions for residents' vehicles and tourist rental cars, the days and hours that the restrictions would be in effect, details of the cost structure, and the logistics of revenue collection.[6] However, because of the controversial nature of such a restriction[7] and difficulties associated with enforcement, this TCM is generally viewed as a last resort.

The effect of this TCM on regional VMT and energy demand could be substantial, depending on details of implementation.

#### 3.4.2.6 High Occupancy Vehicle (HOV) Facilities

Such facilities provide priority to HOVs (e.g., buses, car-pools, and van-pools) by designating lanes, ramps, parking and other facilities for the exclusive use of HOVs during selected hours. HOV facilities increase a travel corridor's people-moving (versus vehicle-moving) capacity. Such facilities improve the service provided by HOVs to make them more competitive with SOVs. Sometimes the HOV improvements are made at the expense of SOVs (e.g. turning mixed traffic lanes into "diamond" lanes).

HOV facilities could be located on freeways or other roads, and can also be dedicated transitways or busways. A recent suggestion is "electric bus flyovers," HOV ramps dedicated to electric buses (Hendrickson, 1993).

The effectiveness of HOV lanes is typically measured by travel time savings. Recent studies (Wilbur Smith Associates, 1992) indicate that the most successful HOV lanes carry three times as many people as a conventional lane. HOV lanes are most effective in dense urban cores with high levels of existing transit/car-pool use, and are much less effective in less densely

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6 Under the original scheme in Singapore, automobiles entering the CBD went to booths where licenses were purchased. Such a technique requires the deployment of collection booths with sufficient queuing area. A "high-tech" improvement to this scheme could be feasible wherein automated detectors would individually identify vehicles passing a checkpoint, and a monthly bill for access to the restricted area would be generated periodically. Such a system would enable implementation of a complex, time-of-day-sensitive rate structure.

7 Implementation of an ALS in Honolulu is currently a heated topic in the press and elsewhere. ALSs can be viewed as highly regressive, a concern that has spawned numerous rebate schemes to lessen their regressivity. The adequacy of viable transportation alternatives in Honolulu, should an ALS be implemented, is also a concern. However, the most recent Waikiki master plan includes a people-mover system, which would provide an alternative to vehicles for trips made within Waikiki.

developed areas. The nature of the enforcement (keeping SOVs out of HOV facilities) also has an impact on HOV usage and effectiveness.

HOV lanes could reduce fuel consumption and emissions. However, if SOV use increases as an indirect effect of HOV incentives, these reductions could be nullified.

The Oahu Regional Transportation Plan (RTP) (OMPO, 1991) describes major expansion plans for the HOV network, from the existing 14 miles in 1991 to 35 miles by the year 2005. SDOT is widening the H-2 Freeway between Mililani and the Wahiawa Interchange to add an HOV lane in each direction, and is also planning for HOV facilities on Nimitz Highway between Keehi Interchange and Pacific Street.

The effect of this TCM on regional VMT could be significant, but resultant improvements in SOV service could generate additional travel.

#### 3.4.2.7 Smart Transit (Smart Street/Vehicle Concepts)

The purpose of Intelligent Transit, also known as Intelligent Vehicle/Highway Systems (IVHS), is to improve roadway performance through state-of-the-art electronic technology and control software. There are four basic categories of IVHS, each with a different application.

- *Advanced Traffic Management Systems (ATMS):* These systems allow quicker incident response through the use of real-time traffic monitoring techniques, areawide surveillance and detection, and integration of a number of freeway operation techniques and increase efficiency of the highway system.
- *Advanced Traveler Information Systems (ATIS):* These systems provide drivers with audio or visual information on congestion, alternate routes, navigation, and roadway conditions.
- *Commercial Vehicle Operations (CVO):* These systems improve the safety and productivity of commercial vehicles through faster dispatching, more efficient routing, hazardous material tracking, and reduced administrative costs.
- *Advanced Vehicle Control Systems (AVCS):* These systems improve safety and increase highway capacity by providing information about changing road conditions, and then using that information to adjust the vehicle's movement.

Each of these technologies is currently under various stages of development and testing. Some major vehicle manufacturers are proposing to install ATIS systems in just a few model years.

Based on a Smart Corridor demonstration project in Los Angeles, it was estimated that the combined use of ATMS/ATIS might reduce congestion and delay times between 20 and 40 percent (Wilbur Smith Associates, 1992).

Application of IVHS-type technology on Oahu is under discussion, and ATMS are being implemented as part of the H-3 project. A project to develop a master plan for IVHS on the island of Oahu is underway. Funding of additional IVHS applications is being sought.

The effect of this TCM on regional VMT is probably minimal.

### 3.4.2.8 Bicycle And Pedestrian Facilities

Programs promoting bicycles and walking as alternative transportation modes typically include the following:

- a clearly designated circulation network linking residential areas with major destinations, such as employment centers, universities, or transit centers;
- safe storage facilities for bicycles at destinations;
- access to convenient, comfortable showers and clothing lockers at destinations; and
- safety amenities such as lighting, barriers, grade-separations, signal preemption, etc.

Bicycle facilities have been constructed throughout the country. Bicycles and walking as alternative transportation modes are particularly popular in university or college-oriented communities.

The ability to transport bicycles on transit vehicles or other HOVs can also be important.

If a system of connected bike paths and sidewalks were available that would be separated from streets, people would be more willing to walk or bike to work, transit stops or shops. Providing facilities for pedestrians, such as paths, crosswalks, benches, landscaping, and fountains, would encourage more trips to be taken by walking rather than by driving. Furthermore, people generally walk farther in a quality pedestrian environment.

On a national average, sixty percent of all vehicle trips are less than five miles (Wilbur Smith Associates, 1992). If 5 percent of these trips could be diverted from cars to bicycles, 3 percent of all personal vehicle trips and 1 percent of all personal VMT and gasoline consumed could be eliminated. Nationally, 7 percent of vehicle trips to work and 11 percent of non-work vehicle trips are less than 1/2 mile (Wilbur Smith Associates, 1992). If 20 - 50 percent of these trips were made by walking rather than driving, overall vehicle trips could be reduced by 2-5 percent, and gasoline consumption reduced by about 1 percent. For every 100 short trips that could be diverted from a car to walking or bicycling, 5-26 gallons of gasoline could be saved, assuming an average of 19 miles per gallon and trips ranging from 1 to 5 miles long.

Certain urban areas in other countries have much greater bicycle use than is typically found in the United States.

Bicycles and walking could also serve as a home and/or work-based feeder mode to a transit stop or center.

Although State of Hawaii, Department of Transportation's 1977 Bikeplan Hawaii: A State of Hawaii Master Plan proposed a 248-mile long bikeway system on Oahu, only about 40 miles have been implemented to date. SDOT revised the bicycle plan in 1994.

In spite of bicycling's potential, the impact of increased bicycle use on automobile travel is viewed as limited due to longer travel times, limited travel range, safety concerns, weather and geographic restrictions, and other factors. Studies in Phoenix, Detroit, and Los Angeles have indicated that about 1 percent of all trips between 1 and 3 miles in length might shift to a bicycle mode in response to inducements (Wilbur Smith Associates, 1992). Depending on the success in implementing a much more extensive bikeway system in Hawaii, the level of interest in bicycling in this state suggests that Hawaii could achieve a greater degree of modal shift to bicycles than areas on the mainland. Consequently, from an energy perspective, the state should pursue its bikeway program. However, the effect of this TCM on regional VMT and energy demand is probably limited.

#### 3.4.2.9 Public Transit Expansion

Oahu

Major transit improvements proposed for Oahu have included:

- expansion of TheBus system;
- a fixed-guideway rapid transit system (Honolulu Rapid Transit); and
- development of a water transit system with terminals along the south shore of Oahu between Hawaii Kai and Barbers Point.

Each of these will be discussed in turn.

Existing transit service on Oahu consists of two systems: TheBus and the HandiVans. Both are under the administration of the Honolulu Public Transit Authority (HPTA), which contracts with private firms to operate each system. TheBus greatly exceeds the HandiVan in terms of fleet size, total route miles, passenger miles, and energy consumption. At present, TheBus consists of 493 buses which travel an islandwide network and are maintained and serviced at two facilities, the Halawa facility, which has capacity for 200 buses, and the Kalihi Palama facility, which has capacity for 250 buses. Local and express services are provided. Annual system ridership is about 73 million unlinked rides, and the system is one of the most highly utilized in the country with 18.2 riders per system mile.

Expansion of the system is largely financially constrained. A study is presently underway which is defining the 5-year capital improvement program for the system. Developing a third bus maintenance facility is the major constraint to system expansion. TheBus recently received 93 new buses, but most of these were used to retire old equipment rather than increase the size of the fleet.

As an immediate response to the demand for additional bus service, HPTA has contracted with private companies for a number of express bus routes to Central and Leeward Oahu.

Expansion of TheBus is consistent with a future rail transit system. If a fixed-guideway system were built, bus routes could be reconfigured to support the fixed guideway system.

Energy savings associated with one scenario of improvements to TheBus system are discussed below. However, apart from energy demand considerations, TheBus is already playing a role addressing Hawaii's energy issues through its participation in the Hawaii Electric Vehicle Demonstration Project (HEVDP). TheBus will be operating a hybrid electric/propane vehicle on the No. 4 route. It should also be noted that the HandiVan system, the smaller existing transit system on Oahu, uses propane.

Energy savings associated with one scenario of improvements to TheBus system are discussed below. However, apart from energy demand considerations, TheBus is already playing a role addressing Hawaii's energy issues through its participation in the HEVDP. TheBus will be operating a hybrid electric/propane vehicle on the No. 4 route.

Planning for a fixed-guideway rapid transit system on Oahu has been ongoing, with some interruptions, for the past 30 years. The system was initially known as Honolulu Area Rapid Transit (HART). Planning of HART occurred from 1977 to 1981, but ceased during the 4-year administration of a rail transit opponent. Planning resumed again in 1986, when the system was renamed Honolulu Rapid Transit (HRT). The HRT proposal had successfully completed the environmental review process, and over $700 million in federal funds were committed to the $1.9 billion project, when the City Council was unable to agree on a local funding source. The project is at present stalled, but attempts to resurrect it could be expected.

Recent studies (1991 and 1992) conducted for the HRT provide data that may be used to analyze the energy consequences of two scenarios of transit improvements. These two scenarios have been analyzed against a future baseline condition that assumes no improvements are made to the transit system on Oahu.

The first scenario assumes that improvements are limited to TheBus. The specific improvements are:

- a bus fleet of 964 vehicles;
- 803 vehicles operating during peak travel periods;
- 8 park-and-ride lots (about 250 parking stalls each);
- express service from park-and-ride lots to activity centers, such as Downtown/Kakaako, the University of Hawaii, and Pearl Harbor; and
- 4 to 6 bus maintenance and/or storage facilities.

The second scenario assumes that the HRT system is built, including the provision of a feeder bus system to the transit stations.

Table 3-3 shows a very approximate comparison of the energy consequences of these two transit options in the year 2005. Table 3-3 shows that both transit improvement scenarios would decrease automobile and passenger truck VMT substantially. The rail transit alternative would be over twice as effective as the all-bus option in reducing this category of VMT. Reductions in energy use would be proportionate.

Savings, however, would be somewhat offset for the all-bus alternative by increases in bus VMT, and for the rail transit alternative, the energy required to run "TheTrain." For the all-bus alternative, the energy required for increased bus VMT would be slightly less than the energy saved through reduced auto and passenger truck VMT, indicating that the all-bus alternative

## Table 3-3

## Changes in 2005 Energy Consumption Due to Transit System Improvements on Oahu

| | Future Baseline | Transit System Improvements: All-Bus | Transit System Improvements: Rapid Transit/Bus |
|---|---|---|---|
| Change in Annual Auto and Passenger Truck VMT | N/A | -57,400,000 | -162,000,000 |
| Change in Annual Auto and Passenger Truck Gasoline Consumption (barrels) | N/A | -63,900 | -180,000 |
| Change in Annual Auto and Passenger Truck Energy Consumption (billion BTUs) | N/A | -310 | -870 |
| Change in Annual Bus VMT | N/A | 6,130,000 | -2,810,000 |
| Change in Annual Bus Diesel Consumption (barrels) | N/A | 37,400 | -17,200 |
| Change in Annual Bus Energy Consumption (billion BTUs) | N/A | 200 | -92 |
| Rail Transit Electrical Energy Consumption (billion BTUs) | N/A | N/A | 670 |
| Annual Ground Transportation Energy Consumption (billion BTUs) | 72,000 | 71,000 | 71,000 |
| Change in Annual Ground Transportation Energy Consumption (billion BTUs) | N/A | -110 | -300 |
| Percent of Future Baseline Ground Transportation Energy Consumption | 100% | 99.8% | 99.6% |

Sources: City and County of Honolulu, Department of Transportation Services, July 1992; Parsons Brinckerhoff Quade and Douglas, Inc., 1994.

Notes:
1) Auto and passenger truck VMT reductions calculated from data presented in the Honolulu Rapid Transit Program Transportation Impacts Results Report, July 1992.
2) VMT reductions taken from automobile and passenger truck classes in proportion to the VMT in each class.
3) Bus VMT changes from Honolulu Rapid Transit Program FEIS, Table 4.1, with the Future Baseline defined as the No-Build Alternative designed to accommodate peak-load-point demand with the same vehicle load standards as the other alternatives (see Footnote 1, Table 4.1). Annual revenue vehicle miles are multiplied by 1.147 to account for non-revenue mileage.
4) Rail transit energy consumption taken from Honolulu Rapid Transit Program FEIS, Section 5.9.
5) Gasoline energy consumption converted to BTUs at a rate of 115,000 BTUs per gallon.
6) Diesel energy consumption converted to BTUs at a rate of 128,000 BTUs per gallon.
7) Electrical energy consumption converted to BTUs at rate of 11,097 BTUs per kilowatt hour.

would save energy, though not a lot. For the rail transit alternative, the energy demand of TheTrain would also be less than the energy saved through reduced auto, passenger truck and bus VMT.

Therefore, based on energy balance calculations, both all-bus and bus-rail transit would save energy, but only slightly. It is important to note that, because of the large power demand of TheTrain, the energy balance results are quite sensitive to the assumed energy consumption efficiency rates. An increase in electrical energy production and transmission efficiency from an assumed current level of 30 percent to a future level of 35 percent would increase energy savings.

However, in contrast to the above analysis which suggests that transit has little impact on gross energy demand, other analyses performed by OMPO suggest that transit, in combination with some roadway improvements to "core" transportation corridors in Honolulu, could produce an energy savings by the year 2020 on the order of eight percent. This analysis, which is based on a combination of transit and roadway improvements, is discussed in more detail in Section 3.5.

In spite of limited energy savings, however, TheTrain alternative could substantially reduce the use of liquid fuel, and replace it with electric energy which could be produced by a variety of fuels. In fact, the very approximate match of "TheTrain's" power requirement and the capacity of Honolulu Project of Waste Energy Recovery (H-POWER) resource recovery facility, plus the observation that the H-POWER facility would be dispatched to meet only peak requirements during the commuting period led to the concept that TheTrain would be "powered by garbage," thereby displacing petroleum. While somewhat misleading, this phrase does point out that, even though rail transit may not generate substantial energy savings, it could potentially displace petroleum in favor of other fuels which could be utilized to make electricity. Such fuel substitution alone would help to achieve Hawaii energy goals. A similar effect could occur with the use of electric buses.

Transit is also almost unique among the TCMs (along with land use patterns) in being able to have market share in all travel markets (home to work, home to school, home to shopping, home to recreation, etc.), thereby providing an alternative to SOVs.

In summary, expanding ground transit on Oahu would substantially reduce regional VMT for autos and passenger trucks to levels below where it would otherwise be at in the absence of the improvements. The bus/rail transit improvements would be over twice as effective in reducing auto and passenger truck VMT as the all-bus improvement option, but either option would have substantial effects. However, the energy requirements of either improvement would require much of the energy saved, although transit expansion would save energy. In addition, the rail transit option (and electric buses) could produce substantial petroleum displacement, depending on the fuel utilized to produce the electricity to power the train or buses. It would be in the state's energy interest, then, to promote rail and electric buses, because the effect could be a substantial reduction in petroleum requirements.

Initial planning for a water transit system consisted of seven ferry terminals stretching from Barbers Point Harbor, along the south shore of Oahu, to Hawaii Kai. Because of issues associated with implementation, the sole link implemented to date has been the one between Barbers Point Harbor and Downtown Honolulu, the link that was projected to have the lowest ridership of any in the total system. Limited service was provided on this route in the summer and fall of 1992. The ferry, Sea Jet I, was operated during peak periods. Actual ridership was even lower than the low ridership that was expected, and the service was discontinued.

The ability of a water transit system to attract SOV users and thereby affect fuel consumption is not known. Net energy effects would depend heavily on ridership, and high velocity ferries with relatively small passenger capacities could be more energy intensive per passenger-mile than ground-based modes.

Neighbor Islands

Ground transportation systems on the neighbor islands are different from those on Oahu in several respects, such as:

- the size of the urban center;
- the distance of travel;
- the existing transportation infrastructure; and
- the population density and distribution.

Hawaii and Kauai Counties operate small bus systems at present. The situation for each County is summarized as follows:

- *Hawaii*: The County of Hawaii Mass Transportation Agency (MTA) administers the Hele-On public bus system. This transit system utilizes ten 42-passenger buses and offers seven routes. The frequency of service is quite limited, with service provided Monday through Friday, one route operating on Saturdays, and no service on holidays. The largest of the two primary providers of specialized transportation services for the elderly and the handicapped is the Hawaii County Economic Opportunity Council, which operates twenty-one vans and mini-buses on a fixed schedule. The other is the Elderly Activities Division of the Hawaii County Department of Parks and Recreation which operates seventeen vans on a demand basis. In addition, State Department of Accounting and General Services (DAGS) contracts with private bus companies to provide school transportation presently utilizing 175 buses. There are also numerous visitor transportation services on the Big Island, such as tour buses, airport shuttles and limousines, and hotel and resort shuttles. Service expansion options are under consideration by MTA for the future, as well as a rideshare program in East Hawaii.
- *Maui*: There is no County-operated public transit on Maui. Most of Maui's HOV transportation services are private or non-profit and primarily serve visitors, the elderly and the handicapped, and students. Currently, Maui Economic Opportunity, Incorporated (MEO), a non-profit organization, operates twenty buses. In addition, the DAGS contracts with private bus companies to provide school transportation utilizing ninety-five buses. There are four major tour bus operators on the island. Airport shuttles are also available. Many hotels, separately and cooperatively, offer shuttle and trolley services to their employees from remote parking areas, and other transportation services for workers from Molokai. Based on existing travel demand, plans for future transit on Maui consist of six additional transit routes and four alternative systems.
- *Kauai*: Before Hurricane Iniki, the County provided two transit lines. One route served employee transportation for the Kilauea Agronomics and Esakai Farms, and the other

served a commuter route between Kapaa and Lihue. The County Office of Elderly Affairs operated an islandwide system on a demand basis for the elderly and the handicapped. The program consisted of ten vehicles, two with wheel chair lifts. However, six days after Hurricane Iniki struck, four separate bus companies began emergency services utilizing 10 buses between the primary communities on the island. The temporary bus system, called the "Iniki Express", now operates 13 buses serving 12 residential communities. It also provides a feeder service that connects the line haul routes centered in Lihue. Based on travel demand projections, eight additional bus routes and six transit system alternatives have been developed.

Based on the Oahu analysis reported above, improvements to the transit systems on the neighbor islands would not generate an appreciable energy savings at the state level.

### 3.4.2.10 Operational Improvements In Transit Service

Efficient and reliable operations increase productivity, cost-effectiveness and attract riders. Operational improvements are generally characterized as service-oriented, roadway-oriented or management actions.

Service-oriented improvements include:

- route and schedule modifications (limited stop and skip/stop operation, altering headways, turn backs, split routes, etc.);
- placement of stops to minimize traffic signal impacts (nearside to farside);
- after-hours "sweeper" services;
- timed transfer hubs to enhance transfer coordination; and
- reduction in number of bus stops.

Roadway-oriented improvements include:

- bus-only lanes which allow buses to bypass congestion;
- elimination of curb parking along bus routes during peak periods; and
- bus-activated signal preemption to improve schedule reliability. (Bus-activated signal preemption is a technology wherein the approach of a bus is detected by the control system of an intersection's signalization — the control system then adjusts signal timing to give the bus "the green.")

An example of a management action to improve transit operations is prepaid fare collection systems.

Improvements in operations can have an impact on corridor-level congestion. Effectiveness depends on a number of factors, including the extent of modal shift from SOVs.

Adjustments and refinements to TheBus' service are ongoing. The transit improvement program for fiscal year (FY) 92 through FY 97 includes an automated vehicle monitoring system, radio system enhancement, and management and information system (MIS) improvements to enhance operations.

The effect of this TCM on regional VMT is not likely to be significant because TheBus is already quite efficient.

### 3.4.2.11 Park-And-Ride Facilities

The City and County of Honolulu operates four park-and-ride facilities located in Hawaii Kai, Wahiawa, Haleiwa, and Mililani. The Hawaii Kai park-and-ride facility opened for service in August 1988. The park-and-ride facility in Wahiawa is shared with the National Guard Armory. The Haleiwa park-and-ride is also a shared-use facility with the Waialua Association Gym. The Mililani facility, completed in January 1994, is located near the Mililani Interchange. A new exclusive-use park-and-ride facility is presently being constructed on land mauka of Royal Kunia subdivision, in central Oahu. The facility opened in December of 1994. The HPTA is the lead City and County agency responsible for developing park-and-ride facilities. The Capital Improvement Program for TheBus includes development of some suburban park-and-ride lots on land dedicated by developers. Plans for the Honolulu Rapid Transit project also included park-and-ride facilities at selected stations.

Park-and-ride lots could greatly enhance HOV options by providing a central rideshare collection point. Park-and-ride lots could be dedicated exclusively for commuter use (Hawaii Kai) or have a shared use, such as a parking lot for a shopping center. (Under limited parking conditions, shopping center management could object to park-and-ride utilization of its lots. Such a position ignores joint development possibilities--see Section 3.4.2.28.)

It is difficult to isolate the effectiveness of park-and-ride lots since they are often implemented synergistically with other TCMs. Park-and-ride lots, in conjunction with HOV lanes, could result in travel time savings, reduced congestion, increased transit patronage, and increased HOV market share.

The effect of this TCM alone on regional VMT and energy demand is probably limited.

### 3.4.2.12 Public Transit Marketing

A transit marketing plan is cost-effective, encourages new ridership, makes service information easier to obtain, improves transit's public image, and satisfies other goals provided there is unused transit capacity.

A marketing program is one of the most important programs undertaken by a transit agency. In New York City, a regional transit guide increased ridership and decreased auto use among those who used the guide (Wilbur Smith Associates, 1992).

The Island-Wide Comprehensive Bus Service Plan (Wilbur Smith Associates, 1988) included a detailed marketing plan. It was recommended that TheBus' marketing budget be increased by 50 percent to fund an expanded marketing program. Currently, TheBus sponsors the Bonus Program, which enables companies to subsidize monthly bus passes for their employees.

The effect of this TCM on regional VMT could be significant but only if it is accompanied by system expansion.

### 3.4.2.13 Paratransit - Premium Subscription Express Bus Service

Paratransit is generally used to describe a broad range of transportation services other than conventional public-sponsored fixed-route transit services. Paratransit strategies are often applied to lower density travel corridors, areas with dispersed travel patterns, or special travel markets.

Premium subscription express buses (also buspools and club buses) typically provide service between suburban communities and large employers or employment centers. This service differs from conventional express buses in that it is private and serves an identified group of riders who generally subscribe to long-term service. Amenities could also be offered. Premium subscription express service could be coordinated with the service being provided by conventional express buses, or provide a "premium" service in a high-demand corridor that already has conventional express buses.

Premium subscription express bus services could increase HOV market share at the expense of SOVs. Premium subscription express bus service could achieve travel times that are competitive with the auto, particularly if HOV lanes could be used to bypass SOV congestion, and could cost less than auto usage. Premium bus service (and ridesharing in general) could reduce expensive peak demands on public bus systems, energy consumption and pollution, and pressure to expand fixed routes into low density areas.

TheBus provides express routes to many outlying residential communities on Oahu from Downtown and/or the U. H. Manoa area. Supplemental express routes are being provided by private contractors, for example, the TransHawaiian Commuter Express, a luxury commuter bus offering service to residents of Leeward and Central Oahu.

The effect of this TCM on regional VMT and energy demand is probably limited.

### 3.4.2.14 Paratransit - Jitneys

Jitneys provide an urban transportation service with characteristics common to both shared-ride taxis and local fixed route buses. Private operation, small vehicles and flat fares are its defining characteristics. Jitneys typically operate along fixed routes in high density urban areas at unscheduled (usually short) service frequencies. They are typically small vehicles (5-20 passengers) and stop when hailed. Jitneys should not be confused with shared-ride taxis, which have distance-based fares.

Jitney service is a paratransit strategy that meets specialized needs. Jitneys could work effectively in lower density interurban areas. Applications include areas without bus service, a substitute service on routes marginal for buses, and a supplemental service along shorter, high-demand segments.

Provided jitneys operate on short headways, they could significantly improve overall travel times. Case studies in the United States indicate that jitneys could provide more frequent and faster services than public transit, in the limited market that they serve (Wilbur Smith Associates, 1992).

A recent OMPO-sponsored study on jitney service on Oahu (Wilbur Smith Associates, 1993c) estimated that if extensive jitney service were established on Oahu, with service being provided only during the peak commuting periods, a vehicle occupancy rate of 1.2 could be obtained. This would be about 0.15 percent of the daily traffic, and 0.5 percent of the peak hour traffic on Oahu. This level of potential benefit, which does not include the additional volumes that would be associated with new jitney movements, would probably not yield perceptible energy savings.

Jitney service in Waikiki has been discussed. The high frequency of stopped jitney vehicles pulling into traffic is perceived as an adverse rather than positive effect on overall traffic flow. Jitney services in Waikiki would compete with transit.

Because jitneys could serve only a limited share of the total travel market, the effect of this TCM on regional VMT and energy demand is probably limited.

#### 3.4.2.15 Paratransit - Shared Ride Taxi

Shared-ride taxis provide a demand-responsive service where two or more unacquainted individuals on different trips share a common vehicle. The concept makes more efficient use of the vehicle which can be passed on in the form of lower passenger fares. The principal difference between shared-ride taxis and jitneys are in the nature of the passenger interface and routing flexibility.

Shared-ride taxis operate on a flexible schedule, as opposed to car-pooling or van pooling, which are scheduled. Shared-ride taxis may be used to provide feeder service to transit stops.

Depending on the specific circumstances, the productivity of a shared-ride taxi can be from 50 to 100 percent higher than a single ride taxi. Shared-ride taxis are significantly more fuel efficient and economical on a per passenger basis than underutilized buses.

A small-scale shared-ride taxi service was initiated in Hawaii around 1990 under the Entrepreneurial Services Program of the Urban Mass Transportation Administration. The one-taxi operation provided collection and distribution service between Mililani Town and a park-and-ride lot. The service was short-lived due to lack of patronage.

The total impact of shared-ride taxi services on regional VMT and energy demand is likely to be small.

#### 3.4.2.16 Guaranteed Ride Home

Guaranteed Ride Home (GRH) programs provide carpool and van-pool patrons with a ride home or to other destinations in an emergency. The intent of the program is to overcome a barrier to ridesharing — the need to get to home, to school, to a day-care center or to another location in an emergency.

The guaranteed trip could be provided through fleet vehicles, short term auto rentals or taxi services. The program is most often offered by employers synergistically, as part of a program encouraging car-pooling, transit, walking and cycling.

Effectiveness of GRHs depends on how much the GRH is pivotal in affecting mode choice. It could promote SOV to HOV switching. It could cause some transit users to shift to car-pools, since the program removes the uncertainty car-pool patrons could have about getting to emergencies. Reduction in energy use would depend on the effectiveness of the program in increasing HOV market share, and reducing regional VMT.

The Leeward Oahu Transportation Management Association (LOTMA) provides a GRH program. LOTMA's GRH program had 124 registered participants in March, 1994. To register for the GRH program, the applicant must be a monthly subscriber of a premium subscription bus service. If an emergency arises, the participant of the GRH program contacts their supervisor, who calls a cab company affiliated with the GRH program to drive the participant to the desired location. The cab company is paid with a GRH program voucher. Three vouchers per year per participant are allowed. The program appears successful in that it has attracted to transit commuters who would otherwise most likely be using SOVs. It is expected to continue.

The effect of this TCM on regional VMT and energy demand is unclear, but probably small.

### 3.4.2.17 Areawide Rideshare Programs

Areawide rideshare programs encourage regional car-, van-, and bus-pooling through computerized matchlists of potential participants, personalized matching services, and focused informational and marketing campaigns. Rideshare programs have taken many forms. They are staffed, funded and/or coordinated by transportation agencies, planning organizations, transit operators, government agencies, and non-profit agencies.

Areawide ridesharing programs best address trips between home-and-work in urban areas of 50,000 or more. Because ridesharing programs target the commuter market, which accounts for about one-quarter of all trips made in urban areas, the impact on regional VMT could be significant. However, recent studies suggest that the market penetration of areawide ridesharing may be relatively limited (Wilbur Smith Associates, 1992).

SDOT's Rideshare Hawaii Program promotes ridesharing during peak hours. Participants contribute to gas and parking expenses, or take turns driving their own cars. The SDOT ridesharing program currently has fifty participants on the database. However, due to a larger number of interested riders than drivers, the majority of program participants cannot be matched to drivers. LOTMA and the County of Hawaii have also been matching carpools for a number of years. The University of Hawaii's Commuter Office, the Waianae Good Neighbor Share-A-Ride program, and Vanpool Hawaii are other carpool matching and vanpool programs on Oahu. The small number of actual participants ridesharing together is expected to have a minimal impact on VMT.

Through FHWA, software and hardware will be purchased to be used by organizations on Oahu and the Counties of Hawaii, Maui and Kauai which organize carpool matching. The software program will enable the organizations to match carpool partners according to their work schedule, place of work or destination, residence and other locations. The software will be hooked up to a mapping program allowing interested people to find out whether co-workers or community members have signed up for carpooling. The software will also make it possible to register and match car-poolers to such events as public meetings or trade shows. As soon as the software equipment is installed, Kauai and Maui will begin providing carpool-matching services to their communities.

The effect of this TCM on regional VMT and energy demand is probably minimal.

#### 3.4.2.18 Controls Affecting Parking Supply

Parking supply controls are designed to discourage SOVs, but sometimes conflict with economic goals. Because of their controversial nature, pricing and supply controls on parking are typically proposed for implementation later, if other strategies have not achieved desired results.

Parking is a critical factor affecting mode choice. Constrained supply and higher prices encourage HOVs. Parking management is most effective when supported by other TSM measures (good transit service, regional rideshare matching, etc.). Because parking strategies are often implemented in concert with other TSM measures, their effectiveness alone is not clear. Cities implementing parking supply reductions in concert with other TSM measures have achieved significant reductions in SOVs.

Parking strategies are best applied in CBDs and other high density areas where land is both costly and scarce, and the parking supply is already constrained. These strategies are less effective in areas of dispersed development and ample parking.

Parking strategies are often implemented with Trip Reduction Ordinances (TROs), which encourage HOV modes (see Section 3.4.2.25).

A recent OMPO study analyzed the effect of establishing maximum parking stall ratios applicable to new office development Downtown and in the Ala Moana-Kapiolani Area (Wilbur Smith Associates, 1993d). The study assumed that limited parking would force commercial institutions to choose between employee and visitor parking. It was assumed that the institution would maintain visitor/customer parking, and forego some employee parking. As a result, when lower parking ratios were applied to proposed new office space, the percent of employees using SOVs was projected to decline marginally during peak hours. The study projected a very slight cumulative impact on area traffic. Under the most severe parking constraint (1 stall to 2,000 square feet), projected traffic in the area could decrease by less than five percent, although it may also result in people driving farther to outlying locations with better parking, thereby increasing VMT.

The effect of this TCM on regional VMT and energy demand is not clear.

### 3.4.2.19 Pricing Actions Affecting Parking

Parking pricing strategies to discourage SOVs include:

- new or increased fees for solo drivers or long-term parkers;
- pricing preferences given to car and van-pools; and
- taxes on parking providers.

The effect of parking pricing on vehicle travel depends on many factors. Case studies suggest municipal parking pricing could be effective in reducing SOVs (Wilbur Smith Associates, 1992). However, pricing strategies could merely divert parking to different times and locations, or foster switching between HOV modes. While peak period surcharges and increases in long-term parking rates reduce commuter auto use, these measures also free parking for short-term parkers, facilitating shopping trips. Net VMT and energy reduction might be less than the proportion of commute trips reduced. When the City of Honolulu doubled long-term parking rates in 1981, the number of long-term parkers declined, but short-term parking increased. The total number of cars parked increased by six percent, and the number of available lunch hour spaces doubled (Di Renzo, 1981).

Pricing for municipal parking is set by City ordinance. Given the small proportion of downtown parking that is under municipal control, modifying pricing on municipal facilities could have very little effect on regional VMT.

The effect of this TCM on regional VMT and energy demand is probably minimal.

### 3.4.2.20 Employer Parking Pricing And Supply Actions

Employers could influence employee travel mode choice through parking strategies. Relatively small increases in parking prices in Honolulu, where prices are already high, could influence travel behavior. Reducing or ending parking subsidies could affect employee travel mode choices. The Alternatives to Employee Parking Subsidies (Wilbur Smith Associates, 1993a) evaluated three pricing options:

- *Charge parking:* Employees are charged at or near market rates.
- *Cash out:* The employer gives employees eligible for discounted parking a choice between the subsidized parking or the subsidy in cash.
- *Charge parking with travel allowance:* The employer charges at or near market rates for employee parking, but also offers a travel allowance on HOVs.

The study estimated possible effects of the three options on morning peak hour traffic to the Financial District, Kakaako, and Waikiki. The estimated reduction in weekday vehicle trips to the three areas varied from 3.6 to 9.9 percent under the different options. The highest reduction would occur in Waikiki under the Charge Parking option. The lowest reduction would occur in Kakaako under the Cash Out option.

Energy savings through parking pricing would depend on the amount of parking that would be displaced, and on the proportion of parkers diverted to new locations, compared to those diverted to HOVs.

The effect of this TCM on regional VMT and energy demand is probably minimal.

#### 3.4.2.21 Employer-Based Rideshare Programs

Employer-based rideshare programs are strategies carried out by employers to reduce solo driving among employees. Programs include:

- encouragement of HOV use;
- guaranteed ride home;
- variable work hours;
- telecommuting; and
- encouragement of cycling and walking.

Successful employer-based programs usually include parking pricing strategies. Employers could carry out these strategies on their own, or in collaboration with an association of other employers, such as a Transportation Management Association (TMA).

Reductions in energy use under employer-based programs would depend on the effectiveness of the programs in reducing VMT. Employer-sponsored TSM measures affect employee commuter trips and not traffic bound for other sites. The size of the employer also appears to play a role in TSM program effectiveness since larger employers have more resources to devote to implementation, and larger numbers of employees facilitate implementation.

Some form of government regulation may be necessary for lasting implementation of employer based programs. Government could require that a certain level of an employer's commutation requirement be provided by non-SOV modes, as arranged and coordinated by the employer. The South Coast Air Quality Management District (SCAQMD) required employers of more than 100 people at a job site to implement a plan to encourage their employees to rideshare to work. The typical ridesharing target is 1.5 average vehicle ridership. This measure has been quite unpopular among employers.

The effect of this TCM on regional VMT and energy demand is probably minimal.

#### 3.4.2.22 Variable Work Hours

Variable work hour programs manage travel demand by:

- shifting commuters away from the maximum periods; or
- reducing the number of work trips by extending the hours worked each day, thereby decreasing the number of days worked. Compressed work week schedules allow employees to work four days per week, ten hours per day.

The three principal forms of variable work hour programs are: staggered hours; compressed work weeks; and flextime.

Variable work hours relieve traffic congestion by shifting commuting out of the peak, thereby reducing travel time. Staggered hours and flex-time would also relieve congestion at parking access points. Variable work hours indirectly affects travel mode choice and non-work trips, making ride-sharing more difficult to implement. Compressed work weeks appear to reduce total VMT.

The evaluation of the 1988 Staggered Work Hours Demonstration Project in Honolulu (Guliano and Golob, 1989) indicated that spreading the peak travel demand period had a beneficial effect on traffic conditions. However, the effect was small and distributed unevenly. It was concluded that the potential benefits of staggered hours did not outweigh the costs of a mandatory program, and that future programs should therefore be voluntary.

Government could promote variable hour programs in the private sector and implement them among their own workers.

The effect of this TCM on regional VMT and energy demand is probably limited.

#### 3.4.2.23 Telecommuting

Telecommuting reduces home-to-work trips by allowing employees to work at home or at telework centers in outlying residential districts. There could be computers, faxes and modems at the telework center. Telework centers may be run by single or multiple employers. Telecommuting could significantly reduce work trips. It affects the working environment and culture of an employer, however, and the degree to which telecommuting would gain widespread acceptance remains to be determined. Telecommuting is more easily encouraged in some industries than others. Telecommuting could affect off-peak and non-work trips.

Government could facilitate telecommuting programs by providing and encouraging telecommuting infrastructure. Government could demonstrate telecommuting for its own employees, as it is doing at the telework center at the Mililani High Technology Center, and develop guidelines for consideration by the private sector.

The effect of this TCM on regional VMT is not clear.

#### 3.4.2.24 Transportation Management Associations (TMAs)

TMAs are groups of public and private parties that address local transportation problems. They typically consist of employers, developers, building owners, officials of transit districts and/or rideshare organizations. They attempt to build consensus for transportation solutions, and political and monetary support for action. They often sponsor transportation services such as:

- car-pool matching;

- shuttle buses to transit lines and/or shopping areas;
- sale of transit passes;
- guaranteed ride home programs;
- promotional events in support of transit, cycling and ridesharing; and
- information on TSM programs.

In 1991, there were about 110 TMAs operating or forming in the United States. Evaluations of TMAs are relatively rare, and it is difficult to quantify changes in travel behavior from TMA implementation. Reductions in energy use would depend on decreases in SOV use.

Government could encourage formation of TMAs. Most TMAs are initiated through informal and voluntary interactions between developers, local governments, employers and transit and rideshare agencies.

The LOTMA, Hawaii's first TMA, was formed as a voluntary non-profit organization in 1990. It contains representation of private landowners and public agencies, and focuses on transportation issues in the Ewa-Central region of Oahu. LOTMA is providing ridesharing and other services, and could provide more services with additional support, an option for state consideration. The state could also initiate other TMAs on Oahu and the neighbor islands.

The effect of this TCM on regional VMT and energy demand could be significant.

#### 3.4.2.25 Trip Reduction Ordinances (TROs)

TROs require employers and/or developers to implement TSM programs. The ordinances typically require:

- an on-site transportation coordinator responsible for implementing TSM programs (e.g., ridesharing, transit pass distribution, variable work hours, parking management, and alternative mode information);
- a periodic survey of employee travel patterns to monitor program effectiveness and employee perspectives; and
- a periodic report to be filed with a public agency to demonstrate effective implementation of TSM strategies.

TROs often specify a goal that must be reached, usually a reduction among employees in the proportion of solo drivers or peak period auto trips.

In 1990 there were at least 23 communities nationwide with trip reduction ordinances, and about 12 others considering their adoption (Urban Land Institute, 1990). Effectiveness depends on many factors. TSM measures tend to be more successful at larger companies. Reduction in energy use would depend on the effectiveness of the programs in reducing VMT.

The Honolulu City Council's Committee on Transportation and Government Operations developed a draft TRO in 1992, but it was not enacted.

The effect of this TCM on regional VMT is not clear.

#### 3.4.2.26 Actions By Educational Institutions

Schools are major contributors to travel demand and congestion on Oahu, particularly in the morning. The University, colleges and private schools generate most school-related vehicle trips. A 1986 OMPO study (Kaku Associates and Barbara Sunderland & Associates, 1986) estimated that school-related trips represent about 30 percent of the total trips to the primary urban center on Oahu, and that private school-related trips were more likely to be made by car than public high school trips.

Educational institutions could implement:

- school hour changes;
- an expanded school bus program; and
- program activities at branch locations.

A more recent study sponsored by OMPO (Wilbur Smith Associates, 1993c) recommended the following TSM measures for the University of Hawaii's Manoa Campus:

- establish a Transportation Task Force, set a program goal, and secure funding; and
- initiate TSM measures, such as ridesharing, flexible class hours, and school bus services.

The effectiveness of these TSM measures was not, however, presented in the study.

The effect of this TCM on the regional VMT and energy demand could be significant.

#### 3.4.2.27 Pricing Or Other Control Of Automobile Use

Road pricing and control strategies include:

- *Road Pricing:* Road users would be charged for some trips. Pricing could vary by time of day, location and vehicle occupancy. Road pricing could be applied to expressways, principal arteries within a congested travel corridor, congested bridges or tunnels leading into central areas, and surface streets within congested zones. IVHS techniques could be employed to detect trips and generate periodic billings to vehicle operators.
- *VMT and/or Emission-Based Vehicle Fees:* Annual charges could increase with miles driven. The fee could replace other vehicle registration fees. It could be imposed at vehicle safety checks, or registration renewal.
- *Fuel Tax Increases:* Fuel tax increases have been used in the past to enhance revenues. Because such taxes are so general in scope and broad in their impact, their use as a TSM is highly controversial.
- *Tradable Travel Permits:* Travel permits for certain congested road facilities or zones at designated times could be allocated up to an allowance. Drivers would be allowed to buy and sell permits.

- *Car ownership controls:* Some have suggested the establishment of a requirement to trade in a used car for each purchase of a new car (Mattheson, 1994). Other possible restrictions could be placed on the number of vehicles per family or per household. These ownership controls would present many implementation issues.

Road pricing could potentially produce the most targeted traffic reductions because it could be made highly location and time specific. In areawide applications, road pricing could be significantly more effective than parking measures because road pricing would affect through trips, as well as trips originating or ending in the CBD. Through trips constitute a significant proportion of trips in most urban areas.

Road pricing is viewed by some as highly regressive because low income groups have legitimate travel needs to zones that would be priced, and often live furthest away. There are various mechanisms for exempting certain population groups or rebating revenues.

Case studies suggest that the effects of road pricing strategies would depend on the level of congestion, level of charges, travel characteristics and alternative travel opportunities. If implemented as a severe disincentive to SOVs, it could be highly effective in reducing vehicle trips and congestion.

Effects of road pricing on energy consumption would depend on how commuters shift between alternative travel routes, and modes and times of travel. "Downtown" areawide road pricing programs could produce ten percent or greater reductions in energy use associated with travel in the area (Wilbur Smith Associates, 1992). Regionwide road pricing programs have the potential to produce a 5 percent or more reduction in energy use (U.S. Environmental Protection Agency, 1990).

Automobile pricing strategies have not been used as TSM measures on Oahu. There was discussion of applying for a federal grant to initiate a pilot program, but there was no local consensus.

Requiring that a used car be traded in for each new car purchase, or establishing some other form of car ownership restriction, does not appear to have much political support at the present time.

The effect of this TCM on regional VMT could be significant, depending on details of implementation.

#### 3.4.2.28 Land Use Patterns And Energy

Treatises have been written about the relationship between land use, energy and lifestyle (see for example Cervero, 1989; Cervero, 1993; Douglas, 1992). All agree that land use patterns profoundly affect transportation energy demand. Across the United States, low-density suburbanization has essentially been designed around a premise of inexpensive use of the automobile, one of the more energy-inefficient transportation modes. Many suburban communities developed when the nation was rather uncritically enraptured by SOVs. Of political interest, SOV disincentives would be particularly linked to lifestyle changes in these types of communities.

Land use patterns that create higher population and workplace densities, and multi-functional neighborhoods, are much more compatible with non-automobile modes of travel. In concept, higher densities and a greater mix of uses could create communities where residences were located closer to workplaces and services. This would decrease VMT and facilitate transit. The best opportunity to create communities amenable to energy-efficient transportation is before the land is developed, since redevelopment is more expensive, problematic and uncertain. Because the state still has extensive open areas that are planned for residential development, there is an opportunity to control this future development by adopting land use policies that encourage non-automobile transportation, and reduce the need to travel. Appropriate land use patterns, zoning, and building codes,[8] the most fundamental way to affect transportation energy demand over the long term, must be implemented over decades.

Table 3-4 summarizes some land use concepts currently being discussed that could reduce transportation energy demand. In general, the land use concepts on Table 3-5 reduce the need to travel, and help transit, car-pooling, walking and bicycling to become viable alternatives to SOVs. The fourth column shows just a few examples of these concepts as they have been or could be applied in Hawaii. Several of the examples highlight Hawaii redevelopment efforts, such as Kakaako.

Many concepts in Table 3-4 consist of mixing land uses, such as residential and workplace. Energy savings could materialize by enabling people to live closer to their workplace. This proximity could encourage walking, biking, and transit, and reduce VMT on those trips which could not be converted from SOVs. In suburban employment centers, higher proportions of workers walked or bicycled to work when on-site housing was available (Cervero, 1989). However, energy savings would not materialize if housing prices did not match the jobs provided nearby, since workers would then need to commute from affordable housing some distance away.

The Kakaako Community Development District is a governmental attempt to redevelop a deteriorating industrial-commercial area into a mixed-use residential-office-commercial-light industrial area where people could live, work, shop and recreate without leaving the area. Kakaako is also less than a mile away from downtown Honolulu, enabling Kakaako residents working downtown to have many transportation alternatives.

Another significant mixed use development on Oahu is Kapolei, a secondary urban center now being constructed in the Ewa district, approximately 20 miles from downtown. There is much local interest in whether this experiment actually achieves its potential to assist in attaining many state goals, beyond those pertaining to energy. Efforts to support Kapolei are evident:

- Government agencies have relocated workers to Kapolei, and more relocations are planned;
- Improvement to Barbers Point Harbor are occurring and planned;
- Road infrastructure improvements are occurring;
- Many of those involved in Kapolei construction have opened branch offices there; and

8 Building codes are included because they affect parking ratios and other design aspects with energy implications.

## Table 3-4

## Selected Innovative Land Use Planning Concepts with Potential for Transportation Energy Savings

| Description | Consequences for Energy Savings | Potential for Hawaii | Source |
|---|---|---|---|
| Mixed residential and employment land uses | Energy savings could occur when people live and work within walking or biking distance | 1) Kaka'ako Community Development District<br>2) Kapolei Secondary Urban Center<br>3) Resort provision of housing for employees | 1<br>2 |
| Shops and services within walking distance of residential areas | If half of 1/2 to 5 mile vehicle trips for shopping and personal business were reduced to below 1/2 mile, total vehicle trips might decline by 5%, and gasoline savings could be between 1-2% | 1) Kaka'ako Community Development District<br>2) Kapolei Secondary Urban Center | 1<br>3 |
| Shops and services near employment centers, transit shops, and park-and-ride lots | If one in ten personal vehicle trips were made on foot as a result of this land use concept, energy consumption due to personal travel could decline by 3% | 1) Kaka'ako Community Development District<br>2) Kapolei Secondary Urban Center | 1<br>3 |
| Locate housing units and increase their density near transit | Nationwide, in 1983, 10.3% of people living within 1/4 mile of transit used transit to get to work | 1) Kaka'ako Community Development District<br>2) Kapolei Secondary Urban Center | 1<br>3 |
| Locate and increase employment near transit | Increase transit patronage | 1) Kaka'ako Community Development District<br>2) Kapolei Secondary Urban Center | 1<br>4 |
| Design land uses with transit access in mind | Increase transit patronage | 1) The Villages of La'i Opua<br>2) Kapolei Secondary Urban Center | 1 |

## Table 3-4

## Selected Innovative Land Use Planning Concepts with Potential for Transportation Energy Savings (continued)

| Description | Consequences for Energy Savings | Potential for Hawaii | Source |
|---|---|---|---|
| Diverse and compact housing | 1) More economically accessible to transit and bus services<br>2) Shops and services could be provided within walking distance<br>3) Carpools and vanpools easier to implement | 1) Kaka'ako Community Development District<br>2) Kapolei Secondary Urban Center | 1<br>5 |
| Grid street system | 1) A grid system instead of a cul-de-sac, collector street system could reduce VMT within a neighborhood by 50-60%<br>2) For every 100 short trips diverted from a car to walking or bicycling, 5-26 gallons of gasoline could be saved | 1) Kapolei Secondary Urban Center | 1<br>6 |
| Bike lanes and paths | At least half of all trips are 5 miles or less in length. If 5% could be diverted to bicycles, a 1% reduction in gasoline consumption could be the result | 1) Kapolei Secondary Urban Center | 1 |
| Bike parking and facilities | Same as above | 1) Kapolei Secondary Urban Center | 1 |

# Table 3-4

## Selected Innovative Land Use Planning Concepts with Potential for Transportation Energy Savings (continued)

| Description | Consequences for Energy Savings | Potential for Hawaii | Source |
|---|---|---|---|
| Pedestrian facilities | If 20-50% of vehicle trips under 1/2 mile could be diverted to walking, overall vehicle trips would be reduced by 2-5% | 1) Kapolei Secondary Urban Center | 1 |
| Creating pedestrian and transit oriented communities | Studies indicate that residents in more compact, mixed use developments use half the gasoline for transportation than comparably sized suburban lower-density development | 1) Kapolei Secondary Urban Center | 1<br>7 |

Sources:
1) California Energy Commission, May 1992.
2) Cervero, 1989.
3) U.S. Department of Transportation, November 1986.
4) U.S. Department of Transportation, August 1991.
5) Holtzclaw, April 1990.
6) Kulash, March 1990.
7) Real Estate Research Corporation, 1974.

- Other Kapolei projects to be started include:

  a) Kapolei Regional Park;
  b) Bank of Hawaii building;
  c) Consolidated Theaters, 16 Screens;
  d) Zippy's Restaurant;
  e) Kapolei Power Center;
  f) Seagull School's child care facility;
  g) Kapolei Police Station;
  h) First Hawaiian Bank building; and
  i) State Public Library.

Fulfillment of Kapolei's promise would depend on its success in developing employment centers, and the actual ability of workers in Kapolei to live in Kapolei.

Opportunity for energy savings also exists in the urban design of this community. However, it appears that provisions have not been made for such measures as higher density housing around transit stops, station placement near homes, and bicycle and pedestrian facilities.

Other major land developments, such as Ewa Marina on Oahu and the Villages of La'i 'Opua on the Island of Hawaii, present an opportunity like Kapolei's to develop energy saving communities, but they also face important urban design issues to be resolved during implementation.

Some of Hawaii's resorts could provide housing for their employees' families close to the workplace. Such company-sponsored residential areas would reduce gasoline consumption by reducing VMT, create an opportunity for efficient HOV shuttle services, and help alleviate the scarcity of affordable housing in Hawaii.

Locating shops and services within walking and bicycling distance of residences is another form of land use mixing that could result in significant transportation energy savings. As an example, higher residential densities near malls could be encouraged. Nationally, 38 percent of all vehicle trips and 29 percent of total VMT are for shopping and personal business, with 60 percent of these trips being between one-half and 5 miles (U.S. Department of Transportation, 1992). If half of these trips could be shortened to under one-half mile, and half of these trips made by walking instead of automobile, reductions in VMT and gasoline usage could be from 1 - 2 percent (U.S. Department of Transportation, 1992). While these figures are based on national averages, this land use combination could save energy in Hawaii.

Another land use combination listed in Table 3-4 involves locating shops and services near work sites, transit stops, and park-and-ride lots. If one in ten of all vehicle trips made for shopping and personal business were made by foot or bicycle, from workplace origins, or while commuting, energy consumption for personal travel could be reduced by 3 percent (U.S. Department of Transportation, 1992). For example, park-and-rides, kiss-and-rides, and transit centers could be located in or adjacent to shopping centers. (For example, Ala Moana Center is both a shopping center and a transit center). Locating restaurants, banks, services, daycare centers, and convenience stores near employment centers could encourage more walking trips, make it easier to combine trip purposes, facilitate ridesharing (since one of the barriers to car-pools is that their home to work routing does not allow for running errands), and encourage transit. Downtown Honolulu succeeds in providing many shops and services within walking distance of workplaces and transit centers, like the Hotel Street Bus Mall.

Locating shops, services and park-and-rides near transit stops could encourage transit use by enhancing convenience. Certain land use practices listed on Table 3-4 could also facilitate the effectiveness of transit. For example:

- Increasing the residential density within one-quarter or one-half mile of express transit stops, which could boost transit ridership at the expense of SOVs. In one study, approximately 10 percent of all people living with 1/4-mile of a station used transit to get to work (U.S. Department of Transportation, 1992).
- Locating employment centers near transit stations.
- Encouraging building designs that facilitate transit, such as providing inviting pedestrian access to the building from a transit stop; eliminating barriers to pedestrian flow around transit stops such as walls, roads and large parking lots; designing transit stops within building complexes; and placing structures closer to transit stops and routes.

The term "joint-development" is used to describe the co-development of commercial and residential uses with a transit station. Commercial/transit joint developments are now quite common. Examples include the World Trade Center (WTC) in New York City. This is an office building where 50,000 people are employed which is served by no less than nine rail transit routes. Battery Park City, a residential development of 7,000 people, is immediately adjacent to the WTC. This joint development complex succeeds in replacing millions of VMT by pedestrian travel.

Private developers could pay for joint development rights,[9] and with appropriate financial arrangements, revenues from joint-development opportunities could be used to support the transit system. Honolulu's rail transit proposal included joint development plans at several of the stations.

Developing higher density residential communities would also result in transportation energy savings. Compact communities are more efficiently served by transit services, have more neighborhood shops and services within walking and bicycling distance of homes, and facilitate the formation of car-pools and van-pools. A study of five San Francisco Bay Area neighborhoods showed that as residential density increased, annual VMT (and therefore fuel consumption per capita) decreased (Holtzclaw, 1990). A 1974 study (Real Estate Research Corporation, 1974) compared communities of approximately 10,000 housing units and found that those living in more compact, mixed-use developments used half the gasoline for transportation of those living in less dense suburban developments.

By providing a network of fully connected streets, such as a grid system, shorter, more direct routes are facilitated. For example, in comparison to a pattern of cul-de-sacs with collector streets, a grid system could reduce VMT generated within a neighborhood by 50 to 60 percent, thereby reducing energy consumption (Kulash et. al, 1990). Terrain features could make such a road network impractical in some areas of the state, however.

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9 Joint development rights can be quite valuable. Tenants and owners will pay a premium to reside or work near a well-designed transit station with a good mix of shops and services. Retail establishments are attracted by the volumes of potential customers that would pass by their door.

In spite of the available land use patterns, it is instructive to examine the experience of Portland, Oregon. Portland's Land Conservation and Development Commission set a goal of zero VMT per capita growth for 10 years (VMT growth would equal population growth), a 10 percent decrease in annual per capita VMT within 20 years, and within 30 years, a 20 percent decrease in annual per capita VMT. Although these policies have been in place for 10 years, VMT growth per capita continued, and was at four percent per annum between 1980 and 1990 (meaning that VMT grew substantially faster than the population), higher than the decade before the policies were put into place.

The effect of land use on regional VMT and transport energy demand is significant.

### 3.4.3 ENERGY-SAVINGS EFFECTIVENESS OF THE IDENTIFIED TCMS

Many of the TCMs (though not all) attempt to influence the choice of a transportation mode. Table 3-5 compares average energy intensities for different travel modes on a national basis, and because information was readily available, parameters for Honolulu's TheBus are also shown. Figure 3-1 graphically compares average energy intensities for the different travel modes.

From Table 3-5, it is apparent that, from an energy perspective, the state should be pursuing inducements and disincentives to shift travelers away from SOVs and onto TheBus, except that capacity is limited. It may be noted that TheBus is 2.2 times more energy-efficient (BTU per passenger-mile) than the average U.S. transit bus system, but at the cost of overcrowding on certain routes at peak times. Service enhancements would be needed for the capacity of the system to handle appreciable numbers of those who could be diverted from their SOVs.

As discussed above in Section 3.1, determining the effectiveness of TCMs is quite difficult. A California attempt is shown in Table 3-6, but these results are based on specific studies done for Los Angeles and San Francisco, and are not applicable to Hawaii. However, within the transportation planning field, an aggressive package of TCMs is typically estimated to have at most a 10 percent impact on regional VMT. Improvements to OMPO's traffic model, new travel demand surveys, and other improvements in the basic transportation planning tools on Oahu are occurring, however, and some results based on new traffic modeling are presented in section 3.5. It is notable that a recent California analysis of ground sector energy demand (California Energy Commission, 1994) also stressed the improvement of transportation planning tools, and did not express confidence in existing numerical estimates of TCM effectiveness.

# Table 3-5

## Passenger Travel and Energy Use in the United States, 1990

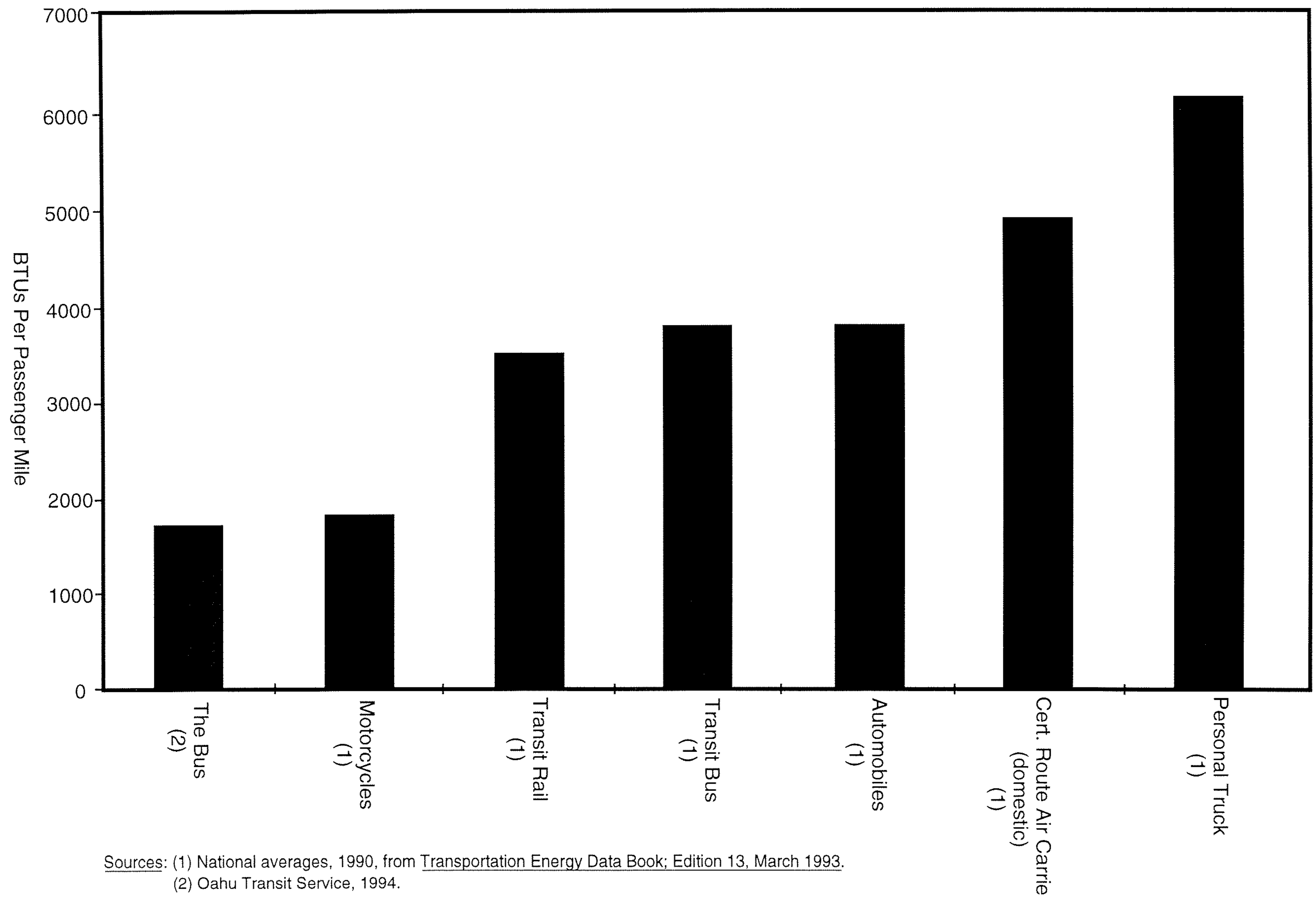
| Travel Mode | Number of Vehicles (Thousands) | Vehicle Miles (Millions) | Passenger Miles (Millions) | Load Factor (Persons/Vehicle) | Energy Intensities (BTU Per Vehicle-Mile) | Energy Intensities (BTU Per Passenger-Mile) | Energy Use (Trillion BTU) |
|---|---|---|---|---|---|---|---|
| Automobiles | 143,549.6 | 1,515,370 | 2,424,592 | 1.6 | 5,983 | 3,739 | 9,0663 |
| Personal Trucks | 27,161.9 | 296,151 | 444,227 | 1.5 | 9,063 | 6,042 | 2,684.0 |
| Motorcycles | 4,259.5 | 9,572 | 13,401 | 1.4 | 2,497 | 1,783 | 23.0 |
| Buses | 588.7 | 6,944 | 18,327 | 17.0 | 23,334 | 1,376 | 23.9 |
| Transit | 59.8 | 2,153 | 21,127 | 9.8 | 36,647 | 3,735 | 162.8 |
| Intercity | 20.6 | 991 | 23,000 | 23.2 | 220,010 | 944 | 78.9 |
| School | 508.3 | 3,800 | 74,200 | 19.5 | 419,677 | 838 | 21.7 |
| TheBus (Honolulu) | 0.472 | 17.5 | 335 | 22.0 | 31,427 | 1,666 | 62.2 |
| Air | [1] | 8,161 | 358,763 | 44.0 | 220,010 | 5,605 | 0.69 |
| Certified Route (domestic) | [1] | 3,964 | 345,763 | 87.2 | 419,677 | 4,811 | 1,795.5 |
| General Aviation | 212.2 | 4,197[2] | 13,000 | 3.1 | 31,427 | 10,146 | 1,663.6 |
| Recreational Boats | 10,134.0 | | | | | | 246.7 |
| Rail | 17.9 | 1,075 | 25,310 | 23.5[3] | 73,581 | 3,125 | 79.1 |
| Intercity | 2.1[4] | 301[5] | 6,057[6] | 20.1[3] | 52,492 | 2,609 | 15.8 |
| Transit | 11.3 | 561 | 12,046 | 21.5[3] | 74,153[7] | 3,453 | 41.6 |
| Commuter | 4.5 | 213 | 7,207 | 33.8[3] | 101,878 | 3,011 | 21.7 |

Source: Transportation Energy Data Book: Edition 13, March 1993 and Oahu Transit Service, 1994.

Notes:
1) Data are not available.
2) Nautical miles.
3) Based on passenger train car-miles.
4) Sum of passenger train cars and locomotive units.
5) Passenger train car-miles.
6) Revenue passenger miles.
7) Large system-to-system variations exist within this category.

## Figure 3-1

## Passenger-Mile Energy Intensities by Travel Mode




Sources: (1) National averages, 1990, from Transportation Energy Data Book; Edition 13, March 1993.
(2) Oahu Transit Service, 1994.

**Table 3-6**

## Estimated Energy Effects of Selected TCMs in San Francisco and Los Angeles

| Policy Type | Effect on Fuel Consumption at Full Implementation |
|---|---|
| Rail Transit System Expansion | 800-1000 fewer gallons per day per mile of fixed rail |
| Rail Transit Access Service | 0.2-0.4 percent reduction in fuel use from extensive subsidy of:<br>1) station-area on-call services<br>2) employer shuttles<br>3) activity center shuttles |
| Bus Transit Headway Improvements | 0.2-0.6 percent reduction in fuel use for a doubling of existing bus frequencies (subject to a threshold average load factor) |
| Fuel Price | 20-25 percent reduction in fuel use for the first $1.00 (1990$) increase in fuel price; about 10-15 percent reduction for the second $1.00 increase |
| Employee Parking Price | 2-3 percent reduction from a $3.00 per day employee parking floor |
| Congestion Pricing | 5-8 percent reduction in fuel use from elimination of all recurring delay |
| Pedestrian-Oriented Development (POD) | 0.04-0.08 percent reduction in total regional fuel use for each 1 percent of new residential development in PODs |
| Increased Density Near Transit | 0.02-0.1 percent reduction in total regional fuel use for each 1 percent of new residential development in higher-density conditions |

Source: California Energy Commission, February 1994.

## 3.5 CONCLUSIONS

This section has presented several strategies for reducing energy demand in the state's transportation sector. While it is of interest to note energy-saving trends in the air and marine sectors, there is little opportunity for state or local governments in Hawaii to effect change in those sectors. Consequently, the state should focus its transportation energy-saving efforts on the ground sector.

The conservation option most powerfully and most easily quantified is improving vehicle fuel efficiency. Regardless of whether VMT could be reduced by other means, substantial amounts of energy would be saved with vehicle fuel efficiency improvements. Implementing vehicle efficiency improvements is discussed in Chapter 11.

It is quite difficult to determine the energy effectiveness of the many TCMs that have been presented in this section, either individually or working in synergistic combinations. Those measures that show the greatest energy-saving potential in the short- and mid-term operate by reducing total regional VMT through travel mode shifts away from SOVs, or by decreasing the need for travel. Different strategies work best on different sectors of the travel market. For example, home to work trips are perhaps best addressed by measures that encourage non-automobile travel models (e.g. transit), and higher utilization rates of automobiles (e.g. rideshare, HOV facilities). Shopping and errand trips are perhaps best addressed through encouragement of non-automobile modes (e.g. transit, walking) and appropriate land use patterns. Home to school trips could be addressed by other options (e.g. HOVs, educational institution actions). Therefore, a complete package to reduce VMT must take into account various trip purposes, the many implementation issues associated with each measure, and the synergies between TCMs. It is notable, however, that transit has a role in almost every travel market.

In addition, if measures are taken to reduce SOVs, alternatives with sufficient capacity and service must be available to satisfy the demand. Therefore, TCM measures must be implemented with a systems perspective.

Because of the update of the Oahu Regional Transportation Plan presently being conducted by OMPO, it is possible to estimate the energy savings associated with certain combinations of TCMs. Estimates of future regional VMT and also data suitable for the method of Shrank, et. al. (1993), which estimates energy waste associated with congestion, have been produced. This analysis indicates that by the year 2020, as much as an 18 percent energy savings could result from an aggressive suite of TCMs, including road pricing. Therefore, aggressive TCMs could substantially affect energy demand.

Improved transit service in association with some roadway improvements could yield a savings of around eight percent, and a rail/bus or electric bus system could displace a substantial amount of petroleum if non-petroleum fuels were utilized to generate the electric power.

Regional VMT has been identified as the key parameter for assessing a transportation project's impact on energy demand. It appears from this analysis that the following offer the most opportunity for decreasing regional VMT and energy demand:

- Public transit expansion;
- Transportation management associations;
- Actions by educational institutions;
- Land use patterns;
- HOV facilities; and
- Automobile use limitations.

Therefore, from an energy perspective, these TCMs should be encouraged. A discussion of whether it is sufficient to merely enhance the attractiveness of HOVs, without also providing disincentives for SOVs, is deferred to Chapter 11.

In conclusion, fleet efficiency improvements, and particular TCMs, including appropriate land use patterns, should all be part of a balanced approach to energy savings. DBEDT should continue to work with SDOT, OMPO and the counties to evaluate the energy impacts of proposed transportation improvements. Also, since fuel prices have an effect on trip generation and/or mode choice, further analysis on the possible impact of fuel price increases on travel behavior and energy demand would be of interest.